INSTRUCTION MANUAL

RADA - NODE
OP-SV Interim

PROPERTY OF THE
TELEMETER
LAB AREA
SHOP 5-4930

KAY ELECTRIC COMPANY

14 Maple Avenue, Pine Brook, N. J.

Noise Diode Head B

	MC	Correction Factor
Approx. Linear	1500	.685
	2000	.615
	2500	.55

10 - 3000 MC

20 DB Max Misr Ant.

The above info was copied from a later Radz Node Manual than the Test Tech. Lab. Manual. Similar curves (correction of transit time effect) appear in Mega-Node St. & "Handbook of Electronic Measr. Vol II" Section 11.

R. Wicklin 12-31-62

Eclipse-Jovoos 7-1

9425 - IT Acc's

Shop 5-4930
TELEMETER AREA
K.Y. Chain Supvr.
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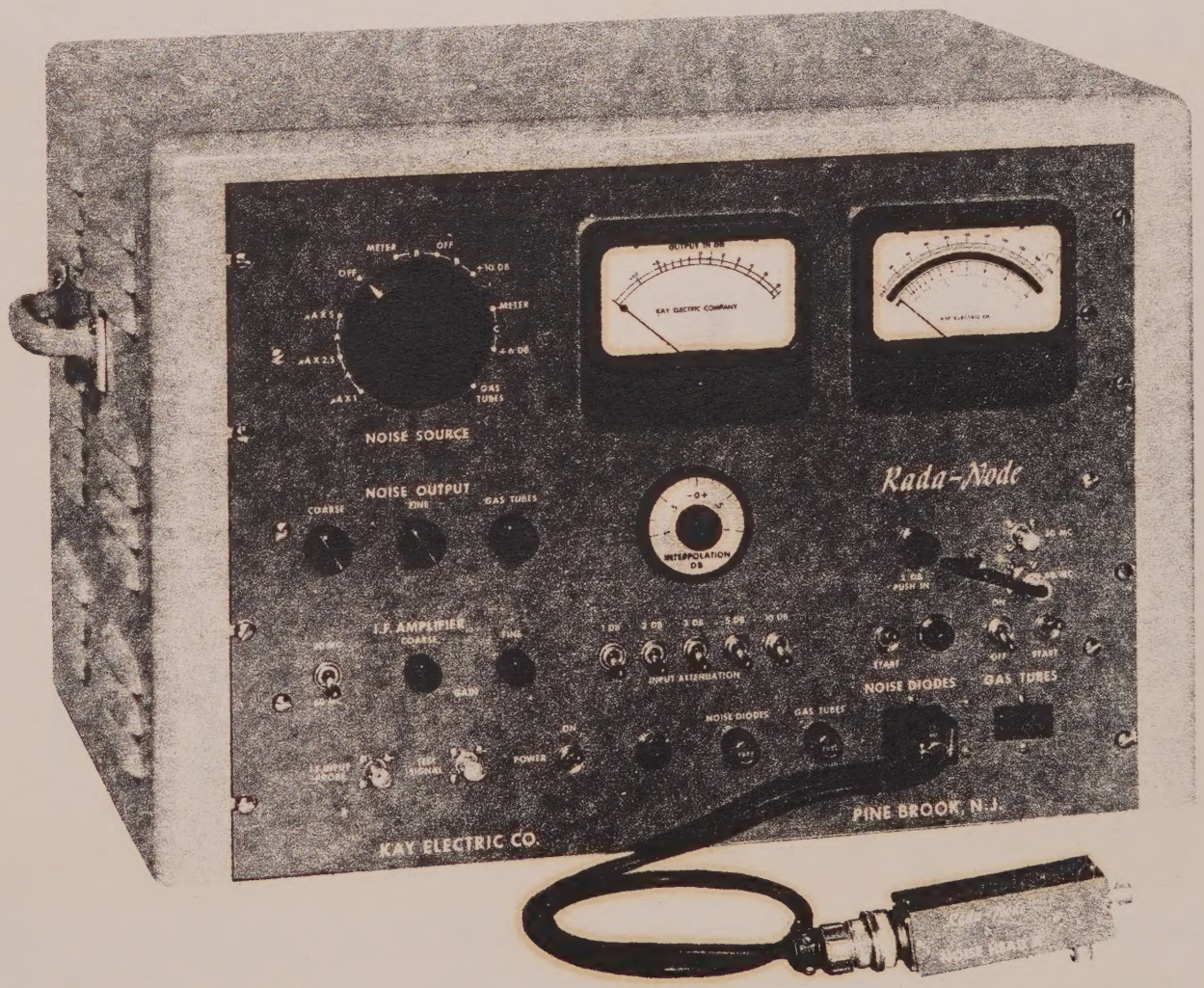
INTERIM
INSTRUCTION BOOK
for the
RADA-NODE

KAY ELECTRIC COMPANY

July 1955

Pine Brook, N. J.


NOISE SOURCE
NOISE OUTPUT
COARSE
FINE
GAS TUBES
INTERPOLATION DB
I.F. AMPLIFIER
COARSE
FINE
GAIN
INPUT ATTENUATION
NOISE DIODES
GAS TUBES
POWER
ON
OFF
START
Rada-Node
KAY ELECTRIC CO.
PINE BROOK, N.J.

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SECTION I

GENERAL DESCRIPTION

A. USES.

The RADA-NODE is a precision noise figure measuring set, primarily designed for testing and aligning equipment receivers. The complete RADA-NODE equipment may be used as a noise source at any frequency in the 5-26, 550 Mc range. Since the RADA-NODE design incorporates complete IF detecting and indicating circuits, it provides all the features normally required for production line or laboratory measurement of noise figure. In addition it includes power supplies for all standard types of noise generators.

B. DESCRIPTION.

The standard equipment of the RADA-NODE consists of two broad-band IF amplifiers, a noise diode power supply, a gas tube power supply, an electronically regulated power supply, an unregulated power supply, an IF probe, and a single noise diode (Noise Diode A) covering the range of 5 400 Mc. By adding optional noise sources, the RADA-NODE may be used as a noise generator operating in the 10-3000 Mc range (Noise Diode B), the 5-220 Mc range (Noise Diode C) or as an r-f noise source with a range of 1200 to 26,500 Mc (gas tubes) covered in eight separate bands. The noise output for the different heads varies from 10-db to 23.8-db as indicated in the specifications below.

The IF input from the circuit under test is fed from the IF probe through a series of six precision switchable attenuators, having a total range of 24-db, to one of the two IF amplifiers. Each IF strip, one centered at 30-Mc, the second at 60 Mc,

has a 14-Mc bandwidth and a gain of approximately 70-db. A 2-db interpolation potentiometer, common to both IF amplifiers, provides a fine degree of inserted attenuation control. Two separate controls, common to both amplifiers, provide independent fine and coarse gain controls for the two IF strips. The detected output is monitored by a zero center db-meter, calibrated from -10 to +6-db. The video output is brought out to the front panel TEST SIGNAL jack. The two IF strips and all four power supplies are enclosed in a single cabinet. Both IF strips are constructed on a single p .g-in unit. Each noise diode or gas tube is a separate assembly, designed to connect directly to one of the front-panel jacks. The IF probe assembly consists of a length of coaxial cable fitted with a BNC connector at one end and a seven-pin tub plug at the other.

C. SPECIFICATIONS.

1. Noise Sources.

	DIODE A*	DIODE B**	DIODE C**	GAS TUBES**
Frequency Range	5-400 Mc	10-3000 Mc	5-220 Mc	1200-26, 500 Mc
Maximum Noise Output	for std. 370 8.7-db	20-db	16-db at 50ω, 23.8-db at 300ω	15.8-db
Output Impedance	Unbalanced 370ω, std.; alternate output impedances may be specified by customer.	Unbalanced 50ω	Unbalanced 50ω 75ω 150ω 300ω Balanced 100ω 150ω 300ω 600ω	SWR 1.1:1

* Supplied
** Available

with equipment as accessory unit

2. IF Amplifiers

Center Frequencies: 30 Mc and 60 Mc

Bandwidth: 14 Mc

Gain: 70 db, approx.

Input Impedance: 50ohms

3. Measurement Controls

a. Up to 24-db total attenuation provided by individual switchable attenuators with 1-db, 2-db, 2-db, 3-db, 5-db, and 10-db values.

b. Zero to 2-db interpolation potentiometer.

4. Power Supplies.

a. Electronically-regulated B+ and filament supply for IF circuitry; B- supply for noise diode A; B+ supply for noise diodes B, and C.

b. Filament power supply for Noise Diodes. Output unregulated 0-10 v.d.c.

c. B+ supply for fluorescent or argon gas tube noise sources.

5. Tube Complement

Main Chassis

18 Type 6AK5	4 Type 6AQ5
2 Type 6AL5	1 Type 6AG5
1 Type 12BH7	1 Type 83
1 Type 6AR6	1 Type 5651

Noise Diodes

Head A	1262A
Head B	TT-1
Head C	5722

Gas Tubes	Fluorescent	Argon
RG-69/U	GE F14T12W	RXB - 103167
RG-48/U	T-8, 15WATT	TD - 12
RG-49/U	T-5, 8WATT	TD - 10
RG-50/U	T-5, 8WATT	TD - 10
RG-51/U	T-5, 8WATT	TD - 11
RG-52/U	T-5, 8WATT	TD - 11
RG-53/U	not available	TD - 13
RG-91/U	not available	TD - 13

6. Dimensions: 15" x 16" x 22"

7. Weight: 70 lbs approx.

SECTION II

INSTALLATION

A. GENERAL.

The RADA-NODE is designed for table top operation and thus presents no special installation problems. However, for optimum operation, the equipment should not be subjected to excessive moisture, vibration or temperature conditions. The installation should include provisions for connection to the circuit under test and to a 160 watt source of 117 volt (±10%), 60-cps, a-c power.

B. INTERCONNECTION DATA.

1. Power Connections. Connect the noise source in use to the appropriate power connector (NOISE DIODE OR GAS TUBE) on the front panel of the main unit.

2. RADA-NODE output connections.

   a. IF Noise Figure Measurements -- Using Heads A, B, or C. The output impedance of the RADA-NODE varies over a wide range of balanced and unbalanced values, according to the noise source in use (See Section I, paragraph C-1). If the input impedance of the circuit under test approximates the one of the available RADA-NODE OUTPUT impedances, make a direct connection from the head OUTPUT jack to the circuit under test. However, if there is a significant difference, (i.e,, ±10%) between the RADA-NODE output impedance and the test

circuit input impedance, a matching device must be inserted in this line. Under either condition, the lengths of all interconnecting cables must be minimized.

b. RF Noise Figure Measurements. Using gas or argon noise sources. All the r-f noise source wave-guides are terminated in standard JAN flanges. Connect one end of the wave-guide directly to the input of the circuit under test. For optimum operation, the impedances of the noise source output and the test circuit input must be matched. The termination of the opposite end of the wave-guide is unimportant.

2. RADA-NODE input connections. The IF probe normally supplied with the RADA-NODE is intended to be used in a seven-pin tube socket in which pin 1 is the grid. For example, in checking an IF amplifier strip, the RADA-NODE IF probe may be plugged directly into the socket of the last IF stage or the second detector if pin 1 is the input to either of these stages. If the stage at which the signal is picked off has its control grid connected to some other pin, the IF probe must be rewired to suit the application.

SECTION III

OPERATION

A. DESCRIPTION OF CONTROLS.

1. NOISE SOURCE Control (S-303). This ten-position rotary switch is used to select one of the four noise sources and to choose the correct meter multiplier scale for the noise source in use. Noise source A, covering the range from 5-400-Mc with a 370-ohm unbalanced output, is the standard noise source supplied with the equipment. Noise source B provides a 20-db output into 50-ohms over the the range from 10-2000 Mc. Noise source C covers the range from 5-220 Mc and provides an output at any of 9 balanced and unbalanced impedances. In addition, any of eight separate gas tubes, covering the spectrum from 1200 to 26,500 megacycles with an output of 15.8-db, may be used as a noise source.

2. IF AMPLIFIER GAIN Controls (R-77, R-78). These two front-panel potentiometers, marked COARSE and FINE, are used to adjust the gain in the first and third stages of both the 30-Mc and 60-Mc IF amplifier strips. When both controls are set completely clockwise, the gain is maximized.

3. IF AMPLIFIER 30-Mc 60-Mc IF switch, (S-1). This DPDT toggle switch is used to apply B+ and filament power to either of the two IF strips, according to the IF frequency of the equipment under test.

4. IF INPUT PROBE Jack (J-2). The BNC plug on the IF probe assembly is connected directly to this UG-185/U receptacle, thus feeding the output of the circuit under test directly

into the RADA-NODE amplifier circuits.

5. TEST SIGNAL Jack (J-3). This UG-185/U BNC connector provides an output for the amplified noise signal coming from either of the IF amplifier strips. It may be connected to the vertical (Y-axis) input of an auxiliary 'scope for monitoring purposes.

6. POWER Switch (S-301). This SPST toggle switch, situated next to the TEST SIGNAL jack, controls the application of all power to the RADA-NODE. When this switch is in the ON (upper) position, the adjacent red light comes on, indicating that a-c power has been applied to the power supplies.

7. INPUT ATTENUATION controls (S-2, S-3, S-4, S-5, S-6). Each of these five DPDT swtiches, marked, 1DB, 2DB, 3DB, 5DB, and 10DB, controls one of the precise, switchable attenuators in the RADA-NODE input circuit. These controls permit the operator to attenuate the output of the circuit under test, in one-db steps, over a range of one to twenty-one db.

8. INTERPOLATION Control (R-81). This potentiometer control is located directly above the five switchable attenuators. It constitutes a continuously variable attenuator which may be used, in determining noise figure, as a vernier to the switchable attenuators.

9. Noise Diode START Switch (S-302). When noise diode A, B, or C is used as a source of noise power, the noise source is energized by momentarily depressing this switch. The adjacent neon light should remain on when the switch is released.

10. NOISE DIODE Connector (j-302). This twelve-pin front-panel jack provides an outlet for the filament, B+ and control voltages required for noise sources A, B, and C. It is normally connected via the interconnecting cable supplied with the RADA-Node to the noise head in use.

11. GAS TUBE ON-OFF Switch (S-305). This SPST controls the output of the gas tube power supply. When one of the eight gas tubes is employed as a noise source, this switch must be in the ON position. It is also used, instead of the power switch, to extinguish the gas tube without having to deenergize the entire equipment.

12. START Switch (S-306). This momentary toggle switch is used to start the gas tube noise source. It is depressed until the gas tube fires, as indicated by the reading of the noise figure meter.

13. GAS TUBE Connector, (J-303). This eight-pin front-panel jack provides an outlet for the filament, B+ and control voltages required for the eight gas tubes. The power cable from the gas tube noise sources is connected directly to this receptacle.

14. NOISE OUTPUT Controls.

    a. COARSE and FINE controls (R-302, R-303). These two front-panel potentiometers provide a means of adjusting the amplitude of noise generated by any of the three noise diode heads. Noise output is maximized when both controls are in their extreme clockwise position.

    b. GAS TUBES control (R-337). This front-panel potentiometer provides a means of adjusting the noise

generated by the gas tube noise source. Noise output is maximized when the control is turned completely clockwise.

15. Meters.

a. IF output meter (M-1). This d-c milliameter, calibrated to cover the range from -10 to +6 decibels, provides a continuous indication of the signal level appearing at the grid of the cathode follower.

b. Noise figure meter (M-301). This d-c milliameter has three separate calibrations. When Noise Diode A is used as a noise source, the uppermost scale, a zero - 200μa calibration, is used to measure plate current before computing noise figure (see paragraph B-12 below). The second scale, a -10 db to +10 db calibration, may be used to read noise figure directly when either noise diode B or C is used as a noise source. The third scale, calibrated in red, indicates the plate current in ma when one of the argon or fluorescent gas tubes is used as an r-f noise source.

16. Fuses (F-301, F-302). The one-ampere fuses for both the main diode power supply and the gas tube power supply are located on the front panel. Failure of either fuse will disable the corresponding power supply and noise source.

17. 30-Mc - 60-Mc I-F Input Connectors (J-5, J-4). These two UG-185/U BNC connectors are the inputs to the two IF strips. The adjacent cable assembly is connected to one of these two receptacles, according to the position of the IF switch (see above) and the I-F amplifier frequency required.

18. 3-DB PUSH IN Switch (S-304). When Noise Diode A is used as a main source, this push button switch is used both to energize the noise head filament supply and to insert an additional 3-db attenuator in the IF input circuit.

B. IF NOISE FIGURE MEASUREMENT. Using Noise Head A, B, or C,

The following instructions are based on the assumption that the equipment under test has either a 30-Mc or a 60-Mc frequency. Under this condition the amplifying, detecting and indicating circuits of the RADA-NODE may be used and no additional equipment is required. However, if the IF frequency of the circuit under test is neither 30-Mc nor 60-Mc, external attenuating, amplifying and power indicating circuits must be used. Note that the external IF amplifier must have the same IF frequency as that of the circuit in question.

1. Connect selected noise diode head to NOISE DIODE jack. Connect the noise diode output to the input of the circuit under test.
2. Connect IF probe assembly to IF INPUT PROBE receptacle.
3. Move the second detector of the circuit under test. If pin 1 of this tube is the input to the detector, insert RADA-NODE IF probe directly into the tube socket. If the detector input is not pin 1, the seven-pin plug must be rewired.
4. Set IF AMPLIFIER toggle switch to either the 30-Mc or the 60-Mc position, according to IF frequency of circuit under test. Use COARSE and FINE IF AMPLIFIER controls to set the noise OUTPUT meter to a convenient arbitrary reference point (near mid-scale).

6. Turn COARSE and FINE noise OUTPUT controls completely counter-clockwise.

7. If Noise Diode A is being used, depress 3-DB PUSH IN switch. This control inserts an additional 3-db pad in the I-F input circuit and energizes the diode A filament circuits.

8. If Noise Diode B or C is being used, insert an additional 3-db attenuation by throwing the 3-DB INPUT ATTENUATION switch to the upper position.

9. Energize the noise diode by depressing the NOISE DIODE START switch momentarily. The adjacent neon indicator should remain on when the momentary swtich is released.

10. Set NOISE SOURCE control to highest meter scale for noise source selected; e.g., A, μA x 2.5 or μA x 5; B, +10DB; C + 6DB.

11. Adjust COARSE and FINE NOISE OUTPUT controls until the OUTPUT meter reading returns to the reference reading determined in step 5 above.

12. When noise diode C is used, the noise figure of the equipment under test may be read directly from the NOISE FIGURE meter. When noise diode B is used, a transit time correction factor must be added to the meter reading. A graph of this correction factor is furnished with each instrument. When noise head A is used, the noise figure may be computed from the formula:

$$F = 20 \log IR, \text{ where}$$

I = the reading of the upper (μA) scale of the NOISE FIGURE meter, expressed in amperes; and,

R = the output impedance of noise head A, normally 370 ohms.

C. RF NOISE FIGURE MEASUREMENT USING GAS TUBES.

The following instructions are based on the assumption that the equipment under test has either a 30-Mc or a 60-Mc frequency. Under this condition the amplifying, detecting and indicating circuits of the RADA-NODE may be used and no additional equipment is required. However, if the IF frequency of the circuit under test is neither 30-Mc nor 60-Mc, external attenuating, amplifying and power indicating circuits must be used. Note that the external IF amplifier must have the same IF frequency as that of the circuit in question.

1. Connect appropriate gas tube assembly to GAS TUBE jack. Connect the output of the gas tube to the input of the circuit under test.
2. Connect IF probe assembly to IF INPUT PROBE jack.
3. Remove ~~first~~ last IF amplifier of circuit under test. If pin 1 of this tube is the control grid, inse t the RADA-NODE IF probe directly into the tube socket. If pin 1 is not the control grid, the seven-pin plug must be rewired.
4. Set IF AMPLIFIER toggle switch to 30-Mc or 60-Mc position, according to difference frequency of test circuit demodulator.
5. Set NOISE SOURCE control to GAS TUBES posttion. Make certain gas tube noise source is not operating by flicking GAS TUBES ON-OFF switch to the OFF position and then back to the ON position. Use COARSE and FINE IF AMPLIFIER controls to set IF NOISE OUTPUT meter to a convenient arbitrary reference point (near center-scale).
6. Set GAS TUBE NOISE OUTPUT control to mid-position. Throw GAS TUBE toggle switch, located above GAS TUBE receptacle, to ON position. Ignite tube by momentarily depressing

GAS TUBE START switch . If the reading on the NOISE FIGURE meter indicates that the tube has not ignited, set the GAS TUBE NOISE OUT-PUT control higher and repeat the starting procedure.

7. After the tube has ignited, adjust GAS TUBE NOISE OUTPUT control until the reading on the red scale corresponds to that listed in the tabulation below.

	ARGON	FLUORESCENT
RG-48/U	250 MA	F > 2.9, 200 MA; F < 2.9, 75 MA
RG-49/U	250 MA	F > 4.5, 200 MA; F < 4.5, 75 MA
RG-50/U	250 MA	200 MA
RG-51/U	200 MA	200 MA
RG-52/U	200 MA	200 MA
RG-53/U	200 MA	
RG-69/U	250 MA	
RG-91/U	200 MA	

8. Use INPUT ATTENUATORS to insert attenuation until the NOISE OUTPUT meter reading back to that obtained in step 5.

9. The noise figure for a fluorescent gas source may then be calculated from the formula:

$$F = [15.84 = .05(T_c - 32)] - 10 \log_{10} (A-1) \text{ db},$$

or for an argon source

$$F = 15.24 - 10 \log 10 (A-1) \text{ db}.$$

Where A is the inserted IF attenuation expressed as a power ratio and T_C is the observed temperature at the noise source at the time of measurement.

10. The formula above is predicated on the assumption of a receiver with only a single response - without spurious responses such as images or harmonic. In actual practice a correction factor must be added. Thus if F is the noise figure obtained above and F_T is the true noise figure, both expressed as power ratios, then

$$F_T = F \frac{B}{BU}$$

Where B is the total bandwidth in cps, including spurious responses, and B_U is the useful channel (signal) bandwidth.

SECTION IV

THEORY OF OPERATION

A. GENERAL.

The operation of the RADA-NODE can be followed more readily by referring to the functional block diagram, figure 3. The RADA-NODE incorporates all the basic elements required in a complete noise-figure test set. The circuits include:

1. Two broad-ban IF amplifiers, centered at 30-Mc and 60-Mc respectively,
2. One to three diode noise sources, operating in the 5-1000 Mc range.
3. A precision attenuator with a total range of 24-db compromising six-fixed switchable pads whose values are additive.
4. A series of eight optional gas tube r-f noise sources, covering the range of 1.2 - 26.5 KMc.,
5. Four separate power supplies, producing B+, B- and filament power for the IF strips and the noise sources.
6. An IF detector probe. In operation, the noise figure is obtained by determining the amount of attenuation required to return the circuit output, when the noise source is energized to a previously established reference level which has been set up with the noise source de-energized.

B. CIRCUIT DESCRIPTION.

1. NOISE DIODE HEADS, A, B, C, (See figure 11). Each of these three noise sources consists of a separate assembly employing a temperature - limited diode to generate random noise for I-F noise figure measurement. The frequency range, power output, and characteristic impedances of each head are listed in Table 1, page 2. The main chassis houses the a-c controls, the metering circuits, and power supplies required by each of these noise diode heads. Each noise diode head is fitted with an a-c power cable assembly which mates with the NOISE DIODE connector on the front panel of the main unit. A coaxial cable on the front of the head provides an output for the generated noise.

2. Gas Tube Noise Sources, (See figure 11). Each of these series of eight noise sources consists of a separate argon or fluorescent noise source, mounted in a standard JAN wave guide, which generates a known level of random noise for r-f noise figure measurement. The frequency range and characteristic impedance of each noise source is listed in Table 1, page 2. The main chassis houses the a-c controls, metering circuits and power supplies required by each of these noise sources. Each assembly is fitted with an a-c power cable assembly which mates with the GAS TUBE connector on the front panel of the main unit. Each wave guide is fitted with a JAN flange (See Table 1), which may be used to couple directly to the circuit under test.

3. I-F Probe Assembly (See figure 8). This assembly consists of a seven-pin plug designed to mate with a standard seven-pin miniature tube socket. The other end of the I-F probe

assembly is connected, via a BNC UG-88/U connector, to the IF INPUT PROBE jack on the front panel of the main chassis. Since pin 1 is the control grid in the majority of seven-pin miniature tubes, the I-F probe sssembly is supplied with the BNC output connector wired to pin 1 of the seven-pin plug. However, the assembly may be rewired in the field to suit the circuitry undertest.

4. INput Attenuator. The incoming signal from the IF probe is fed into a series of five, additive, precision attenuators, each controlled by an individual, front-panel switch (S-2, S-3, S-4, S-5, S-6). These attenuators, rated at one db, two db, three db, five db, and ten db, provide a 21-db range of attenuation in one-db steps for the incoming signal. The output of the last switchable attenuator is connected via a coaxial cable assembly to the sixth attenuator, a three-db pad controlled by the 3 DB PUSH IN push-button switch on the front panel. This attenuator is utilized only when noise diode head A is used as a noise source. The output of this attenuator is coupled, via two separate coaxial cable assemblies to the 30-Mc and 60-Mc IF strips.

5. IF Amplifiers. These two broad-band IF strips centered at 30-Mc and 60-Mc respectively, differ only in the values of grid inductance added to the amplifying stages. In all other respects, they are identical. Each strip has a 14-Mc bandpass and comprises eight 6AK5 stages of amplification, providing a gain of approximately 70-db. Since the plate and filament supplies of both strips are controlled by the

position of the IF AMPLIFIER switch, S-1, only one strip is energized at a time. The COARSE (R-78) and FINE (R-79) IF GAIN controls provide the cathode-to-ground resistance in the first and third amplifiers of each strip and thus may be used to control the gain of the entire strip. Similarly, the INTERPOLATION control (R-81) and the internal 30-Mc., 1-db set control (R-38) and (R-40) may be used to adjust the cathode voltage in the fifth amplifier of each circuit. The INterpolation control functions as a fine gain control for the strip in use. After passing thru eight stages of amplification, the signal in each channel is detected by a 6AL5 diode and fed to the NOISE OUTPUT meter. The reading on this meter may then be used to calculate the noise figure as described in paragraphs B and C of SECTION III, OPERATION.

6. Power Supplies. The RADA-NODE includes four separate power supplies which furnish B+, B-, and filament power for the IF strips, the noise diodes, and the gas noise sources. These supplies include:

   a. Filament and B+ supply for the gas tubes.
   b. A B+ filament supply for the two IF strips and a B+ supply for heads B and C.
   c. Filament power for the three noise diode heads.
   d. A B- supply for Noise Diode A.

C. THEORY OF NOISE FIGURE MEASUREMENTS.

The thermal noise energy of an ideal conductor (one that generates no noise of its own other than that due to thermal activity of the individual electrons) may be stated as a function of the

absolute temperature (T) in degrees Kelvin and the bandwidth (B) of the generated noise in cps. The available noise power from an ideal signal generator may be formulated as:

$$N = KTB \qquad \text{(eq. 1)}$$

where K = Boltzman's constant = 1.38×10^{-23} joules/degree Kelvin

However, in any circuit incorporating a vacuum tube (as contrasted to an ideal conductor), an additional amount of noise will be generated as a consequence of the greater randomness of electron travel in the tube. Then in such a circuit, the noise figure - a figure of merit which measures the additional noise generated in an actual rather than an ideal circuit - may be defined as:

$$F = \frac{\text{available signal to noise ratio at } \sout{\text{output}}\ \text{INPUT}}{\text{available signal to noise ratio at output}} \qquad \text{(eq. 2)}$$

This basic equation can be modified in a number of ways, depending on the method used for making the particular measurement. For example, in using a temperature-limited diode such as heads A, B, or C as as noise source, the noise figure may be expressed as a noise voltage ratio. Since the available noise power range from the signal,

$$N = \frac{E_t^2}{4R},$$

where E_t equals the rms thermal noise voltage and R is the internal resistance of the source in ohms, then equation (1) may be written as,

$$\overline{E_t^2} = 4kTR_sB \qquad \text{(eq. 3)}$$

If the noise generated within the receiver is considered as an rms noise voltage, E_n, then the noise figure

$$F = \frac{E_n^2}{E_t^2}$$

The value of E_n is determined by measuring the noise power output of the receiver with the noise source de-energized but connected to the receiver thru the signal source impedance R_S. The noise source is then turned on and the diode d-c plate current, I_b, increased until the receiver noise power output is just doubled. Then the mean squared noise current of the diode is given by the expression:

$$i^2 = 2e\,BI_b \qquad \text{(eq. 5)}$$

where i = the rms noise current in amperes

e = the charge on an electron = 1.6×10^{-19} coulomb

I_b = the d-c diode plate current in amperes

The mean squared voltage developed across the internal impedance of the source R_s, will be

$$E_n^2 = (iR_s)^2 = 2eI_bBR_s^2 \qquad \text{(eq. 6)}$$

Substituting equation (3) & (6) in equation # (4),

$$F = \frac{eI_bR_s}{2KT} \qquad \text{(eq. 7)}$$

Since the noise figure varies less than ±5% (±0.2-db) over a temperature range of 270-300°K (26-80°F), it is usually permissable to assume T equal to room temperature (290°K, 17°C or 63°F), reducing equation (3) to

$$F = 20\,I_bR_s \qquad \text{(eq. 8)}$$

Since the value of F given by equation (8) is a power ratio, it may be expressed in db by the relationship,

$$F_{db} = 10\log_{10}F \qquad \text{(eq. 9)}$$

These relationships are the basis of the procedure outlined in Section III, Operation, paragraph B, describing the method for making an IF noise figure measurement when a temperature-limited diode (head A, B, or C) is used as a noise source.

Similarly, when a fluorescent lamp, argon tube, or other "hot-body" noise source is used, the noise figure may be stated as a function of the relative power outputs of the noise source and the network under test, (a), when the noise source is at room temperature and (b), when the noise source is energized.

$$F = \frac{\frac{T_h}{T_c} - 1}{A-1} \qquad \text{(eq. 10)}$$

where T_h is the temperature of the energized noise source in K°,

T_c is the temperature of the de-energized noise source

A is the ratio of noise power output from the circuit under test under conditions (a) & (b), i.e., the amount of attenuation required to keep the circuit noise power output invariant.

Since T_c may be taken as $290^\circ K$, as stated above, and T_K has been shown by Mumford and others to be approximately $11{,}400^\circ K$, equation (10) reduces to

$$F = \frac{38.3}{A-1} = 15.84 \text{ db} - 10\log_{10}(A-1)\text{db}, \qquad \text{(eq. 11)}$$

the equation provided in Section III, paragraph C,

Note that both equations (8) and (11) are predicated on the assumption that the image is completely rejected.

SECTION V

MAINTENANCE

A. TROUBLE LOCATION.

If the operation of the RADA-NODE appears to be defective in any respect, first ascertain that the cause of improper operation is not in the circuit under test, the interconnecting cables or other accessory equipment. If a process of elimination indicates that the trouble originates in the RADA-NODE, make the following preliminary checks:

1. Check the operation of all RADA-NODE circuits to determine the exact nature and extent of the defect.
2. Make a visual check to determine that all filaments are lit and that there are no loose connections or obviously damaged components.
3. Check the voltage level at the a-c line, the B+ input, the B- input and the noise diode d-c filament supply.

The most common troubles encountered with the RADA-NODE are weak or defective tubes and occasional misalignments. The trouble-location chart below may be used as a guide to isolate the trouble to a particular circuit or stage. Figure 8, a complete schematic of the RADA-NODE IF circuits, indicates the normal voltage measurements at significant points in the circuitry. The physical location of all tubes, potentiometer, switches and other major components is indicated on figures 4, 5, 6, and 7, the component location diagrams. Complete schematics of the four power supplies used with the RADA-NODE are shown in figures 9 and 10. Schematic diagrams of the noise diodes and gas noise sources are shown in figure 11.

B. ALIGNMENT AND ADJUSTMENT.

1. Test Equipment Required:

   a. Precision attenuator, with 51-db range & 50-ohms impedance (KAY ELECTRIC MODEL 21 or equivalent)

   b. Wide-band oscilloscope.

   c. KAY Electric RADA-SWEEP (with 30-Mc & 60-Mc center frequencies and crystal-controlled markers at 23, 30, 37, 53, 60, and 67-Mc) or equi alent sweeping oscillator.

   d. Zero - 1 ma d-c milliameter.

   e. Vacuum tube voltmeter.

2. B+ Adjustment. Set potentiometer on deck of the IF B+ supply to produce 300-volt output at pin 6 of P-301, the main power connector. Then adjust potentiometer R-340 in grid of V-301 for 140-volt output at the cathode (pin 1) of V-301.

3. IF Amplifier Alignment: The alignment of these circuits should be checked each time a tube or other major component is changed. With the exception of the three interpolation control adjustments R-38, 30-Mc, (± 1 DB set), R-40 (60-Mc ±1 DB set) and R-81 (the front-panel INTERPOLATION control), the two strips are completely independent of each other. Note that whenever the 30-Mc ± 1db, set control (R-38) is readjusted, the 60-Mc, ±1db set control must be readjusted subsequently.

   Before the IF strips can be adjusted, the oscilloscope should be calibrated to provide an easy reference voltage indication. This can be done by feeding the output of a KAY ELECTRIC RADA-SWEEP or equivalent sweeping oscillator

thru a detector to the vertical (Y-axis) input of the 'scope, (see figure 2), and then adjusting the 'scope controls until the pattern is a convenient height, e.g., twenty squares. The IF strips may then be aligned as described below.

a. Connect output of RADA-SWEEP or equivalent sweeping oscillator to a 200 ft. length of RG-8/U and, via a detector box, to the vertical (Y-axis) input of the 'scope (see figure 2). Set RADA-SWEEP CENTER FREQUENCY control to 30-Mc position. Adjust 'scope controls until pattern on cathode ray tube is 20 squares high.

b. Connect TEST SIGNAL jack on front-panel to opposite end of the RG-8/U cable.

c. Connect front-panel patch cord to the 30-Mc I-F jack. Set the IF switch to the 30-Mc position, Energize 23-Mc 30-Mc & 37-Mc markers on RADA-SWEEP.

d. Adjust variable capacitor C-1 and core of tunable inductance L-28 until envelope is flat from 23 to 37 Mc and has an amplitude of approximately four squares. Retouch each adjustment until the best compromise between flatness and minimum amplitude is obtained.

e. Set IF switch to 60-Mc position. Remove patch cord from 30-Mc jack and connect cord to 60-Mc jack. Set RADA-SWEEP CENTER FREQUENCY control to 60-Mc position. Energize 53-Mc, 60-Mc and 67-Mc markers, and deenergize the 23-Mc, 30-Mc, and 37-Mc marker.

f. Adjust variable capacitor C-45 and core of tunable inductance L-29 until envelope is flat from 53 to

67-Mc and has an amplitude of approximately two squares. Retouch each adjustment until the best possible compromise between flatness and minimum amplitude is obtained.

g. Remove coil of RG-8/U. Connect RADA-NODE TEST SIGNAL jack directly to the vertical (Y-axis) input of the scope. Connect the sawtooth sweep voltage from the RADA-SWEEP OUTPUT terminals to the horizontal (X-axis) input of the 'scope.

h. With the RADA-SWEEP CENTER FREQUENCY control set to 30-Mc position, energize 23-Mc, 30-Mc, and 37-Mc markers, and connect SWEEPING OSCILLATOR OUTPUT jack to IF PROBE connector of RADA-NODE.

i. Adjust 30-Mc ±1-db set potentiometer (R-38) and 60-Mc ±1-db set potentiometer (R-40) to the midpoint of their ranges. Both potentiometers are located near the bottom of the left side of the chassis.

j. Set COARSE and FINE IF GAIN controls completely clockwise, e.g., at maximum gain position. Set front-panel INTERPOLATION control at the mid-point of its range.

k. Adjust core of tunable inductors L-2, L-3, L-4, L-5, L-6, L-7, L-8, and L-9 in order until the response curve is within three db over a range of 23 to 37-Mc range and amplitude is maximized.

l. Gain of IF strip, measured by precision attenuator inserted in line between RADA-NODE TEST SIGNAL JACK and vertical (Y-axis) input of 'scope, should be approximately 70-db. Do not use RADA-SWEEP

attenuator to make this measurement.

m. Switch front-panel patch cable from 30-Mc to 60-Mc jack. Set IF switch to 60-Mc position. Set RADA-SWEEP CENTER FREQUENCY control to 60-Mc position. Energize 53-Mc, 60-Mc and 67-Mc, markers on RADA-SWEEP; deenergize 23-Mc, 30-Mc, and 37-Mc markers.

n. Adjust cores of tunable inductors L-15, L-16, L-17, L-18, L-19, L-20, L-21 and L-22 until response curve is maximized and flat to within 3-db over the 53 to 67-Mc range.

o. Gain of strip measured by precision attenuator inserted in line between TEST SIGNAL jack & vertical (Y-axis) input of 'scope, should be 70-db.

p. Reset all RADA-NODE and RADA-SWEEP controls for 30-Mc operation.

q. With all inppt attenuators off and with front-panel INTERPOLATION control (R-81) set at +1db, adjust both FINE and COARSE IF GAIN controls (R-78 and R-79) until NOISE OUTPUT meter reads zero. Throw 2-db INPUT ATTENUATOR switch (S-3) to upper position.

r. Set INTERPOLATION control to -1db position. Adjust internal 30-Mc ± 1db set potentiometer (R-38) until NOISE OUTPUT meter reads zero.

s. Remove 2-db INPUT ATTENUATOR. Set INTERPOLATION control back to +1db position. Adjust FINE IF GAIN (R-79) control until meter reads zero again.

t. Repeat steps q thu s until meter reading changes exactly 2-db as INTERPOLATION CONTROL is changed from -1db to +1db positions.

u. Reset all RADA-NODE and RADA-SWEEP controls for 60-Mc operation. Following a procedure similar to that outlined in steps q thru t, adjust internal 60-Mc ± 1db, set POTENTIOMETER (R-40) until front-panel INTERPOLATION provides proper control of 60-Mc output over 2-db range. DO NOT ALTER SETTING OF INTERNAL 30-Mc POTENTIOMETER, setting of this potentiometer affects calibration of the INTERPOLATION control on 60-Mc operation.

4. Noise Diode Head A

a. Adjust slide on variable resistor R-313 until entire resister is in circuit.

b. Connect Noise Head A assembly to NOISE DIODES jack (J-302) on front-panel of main unit.

c. Remove six machine screws in bottom cover of Noise Head A.

d. Set NOISE SOURCE control to A, μA x 5 position.

e. Turn COARSE and FINE NOISE OUTPUT controls (R-302 and R-303) completely clockwise.

f. Disconnect the lead pin 4 of the NOISE DIODES panel jack. Insert a zero-1 ma d-c milliameter between pin 4 and the disconnected lead, connecting the positive terminal of the meter to pin 4 of the panel jack.

g. Set shunt potentiometers R-317 and R-318 completely clockwise.

h. Energize the Noise Head A by momentarily depressing the NOISE DIODES START switch (S-302). After a 30 second warm-up period, depress the 3-DB PUSH IN switch.

i. Adjust slide on variable resistor R-313 until voltmeter reads approximately 1.2 volts. Maximum must not exceed 1.4 volts.

j. On top deck of main chassis, adjust A, preset high potentiometer (R-304) for reading of slightly more than 1 ma on external milliameter.

k. Set NOISE SOURCE control to A, μA, x 2.5 position. On top deck of main chassis, adjust A preset mid-potentiometer R-305 for reading of approximately 0.55 ma on external milliameter.

l. Switch NOISE S URCE control to A, μA x 1 position. On top deck of main chassis, adjust A preset low potentiometer, R-306, for reading of approximately 0.22 ma on external milliometer.

m. Return NOISE SOURCE control to A, μA x 5 position. Adjust FINE NOISE OUTPUT control R-303 until external meter reads exactly 1 ma. Then adjust meter shunt potentiometer R-317 until NOISE FIGURE meter reads exactly 200 μA.

n. Set NOISE SOURCE control to A, μA x 2.5 position. Adjust FINE NOISE OUTPUT control until external meter reads exactly 0.5 MA. Then adjust internal meter shunt R-318 until NOISE figure meter reads exactly 200 μA.

o. Set NOISE SOURCE control to A, μA x 1 position. Adjust FINE NOISE OUTPUT control until external meter reads exactly 0.2 Ma. If the external meter is assumed to be accurate and the noise FIGURE meter within tolerance, the latter will now read 200 μA, ±2%.

5. Noise Diode Head B

a. Adjust slide on variable resistor R-311 until entire

resistor is in circuit.

b. Connect NOISE HEAD B assembly to NOISE DIODES jack on front panel of main unit.

c. Connect vacuum tube voltmeter across pins #11 and #2 of NOISE DIODES jack (J-302).

d. Set NOISE SOURCE control to B, +10 DB position.

e. Turn COARSE and FINE NOISE OUTPUT controls (R-302 and R-303) completely clockwise.

f. Disconnect lead from pin 7 of NOISE DIODES panel jack, (J-302). Insert 0-150 ma milliammeter between pin 7 and the disconnected lead, with the positive terminal of the meter connected to pin 7.

g. Set shunt potentiometers R-324 and R-325 completely clockwise.

h. Energize Noise Head B by momentarily depressing the NOISE DIODES START switch, (S-302).

i. Adjust slide on variable resistor R-311 until voltmeter reads approximately 3.2 volts. Reading must not exceed 3.4 volts. D.C.

j. On top deck of main chassis, adjust B preset high potentiometer R-308 until milliammeter reads approximately 110 Ma.

k. Switch NOISE SOURCE control to B, METER position. Energize head again by momentarily depressing NOISE DIODES START switch.

l. On top deck of main chassis, adjust B preset low potentiometer R-307 until external milliammeter reads approximately 11 ma.

m. Set NOISE SOURCE control on B, +10 DB position.

Energize noise diode by momentarily depressing NOISE DIODES START switch.

n. Adjust FINE NOISE OUTPUT control until external meter reads exactly 100 ma. Then adjust meter shunt potentiometer R-325 until NOISE FIGURE meter reads exactly 10-db.

o. Set NOISE SOURCE control to B, METER position. Energize noise diode by momentarily depressing NOISE DIODES START switch.

p. Adjust FINE NOISE OUTPUT control until external meter reads exactly 10 ma. Then adjust internal meter shunt potentiometer R-324 until NOISE OUTPUT meter reads exactly 10-db.

6. NOISE DIODE HEAD C.

7. Gas Tube NOISE SOURCES---Argon Sources.

a. Remove lead from pin 1 of GAS TUBES panel jack (J-303). Insert zero-500 ma milliammeter between pin 1 and ground.

b. Plug gas tube assembly cable into GAS TUBES panel jack. Set NOISE SOURCE control to GAS TUBE position.

c. Depress GAS TUBES START switch and hold down while adjusting filament current. Set potentiometer R-334 for the filament current shown in the tabulation below. When the START switch is released, the tube should remain lit.

d. By varying the GAS TUBES NOISE OUTPUT control R-337, the gas tube current should be adjustable over the following range.

WAVE GUIDE	DIODE	FIL. I, MA DC	ANODE I, MA DC OPTIMUM AVERAGE	RANGE
RG-49/U RG-50/U	TD-10	170 ma.	250	125-275
RG-51/U RG-52/U	TD-11	170 ma.	200	125-275
RG-53/U RG-91/U	TD-13	170 ma.	200	125-275

e. Deenergize the gas tube by throwing the GAS TUBES ON-OFF switch o OFF position.

f. Set shunt potentiometer R-338, completely clockwise (i.e., for minimum resistance). Insert 0-500 ma meter between pins 1 and 7 of GAS TUBE power jack, connecting the positive side of the meter to pin 1.

g. Energize gas tube again by depressing GAS TUBES START button. Adjust GAS TUBE NOISE OUTPUT control R-337 until external meter reads exactly 250 ma. Then adjust

internal shunt R-338 until panel meter has identical reading.

8. GAS TUBE NOISE SOURCES--Fluorescent Sources.

   a. Meter shunt must be adjusted as outlined in paragraph B-7 before proceeding with this alignment.

   b. Remove lead from pin 1 of GAS TUBE panel jack J-303. Insert zero-500 ma milliammeter between pin 1 and the disconnected lead, with the positive terminal of the meter connected to pin 1.

   c. Connect fluorescent noise source assembly cable into GAS TUBES jack. Set NOISE SOURCE control to GAS TUBES position.

   d. Depress GAS TUBE START switch and check filament current under START condition. Filament current should be approximately 160-ma. Release START switch. Space current should be approximately 200 ma.

SECTION VI

PARTS LIST

A. I-F STRIP

1. Resistors (Unless otherwise indicated all components are 1/2 watt, fixed, 10% tolerance, composition resistors).

R-1	390
R-2	1.5K
R-3	15
R-4	100
R-5	27
R-6	1.5K
R-7	100
R-8	3.9K
R-9	27
R-10	1.5K
R-11	15
R-12	100
R-13	27
R-14	1.5K
R-15	100
R-16	3.9K
R-17	27
R-18	1.5K
R-19	not used
R-20	10
R-21	27
R-22	1.5K
R-23	100
R-24	3.9K
R-25	27
R-26	1.5K
R-27	not used
R-28	27
R-29	1.8K
R-30	100
R-31	3.9K
R-32	8.2K
R-33	2.2K
R-34	10K
R-35	100
R-36	15K, 2W
R-37	300
R-38	5K, Pot. 30-Mc ±1DB Set
R-39	270
R-40	5K, Pot. 60-Mc ±1DB Set
R-41	12K, 2W
R-42	330
R-43	1.5K
R-44	15
R-45	100
R-46	27
R-47	27
R-48	1.5K
R-49	100
R-50	3.9K
R-51	1.5K
R-52	15
R-53	100
R-54	27
R-55	1.5K
R-56	100
R-57	3.9K
R-58	27
R-59	1.5K
R-60	not used
R-61	100
R-62	27
R-63	1.5K
R-64	100
R-65	3.9K
R-66	27
R-67	1.5K
R-68	100
R-69	27
R-70	1.8K
R-71	100
R-72	3.9K
R-73	8.2K
R-74	2.2K
R-75	10K
R-76	100
R-77	68K
R-78	2K Pot. COARSE IF GAIN
R-79	500 Pot. FINE IF GAIN
R-80	180
R-81	200, Pot. INTERPOLATION
R-82	51
R-83	931
R-84	6.18
R-85	931
R-86	467
R-87	12.43
R-88	467
R-89	313
R-90	16.9
R-91	313
R-92	191
R-93	32.5
R-94	191
R-95	103
R-96	76.4
R-97	103

A. I-F STRIP, (continued).

2. Capacitors (All capacitors in μμf unless otherwise indicated).

C-1	7-45 variable	C-45	7-45 variable
C-2	1000 feed thru	C-46	1000 feed thru
C-3	1000	C-47	1000
C-4	1000, feed thru	C-48	1000, feed thru
C-5	1000	C-49	1000
C-6	1000, feed thru	C-50	330
C-7	330	C-51	1000, feed thru
C-8	1000, feed thru	C-52	330
C-9	330	C-53	1000
C-10	1000	C-54	1000, feed thru
C-11	1000, feed thru	C-55	330
C-12	330	C-56	1000
C-13	1000	C-57	1000, feed thru
C-14	1000, feed thru	C-58	330
C-15	330	C-59	1000
C-16	1000	C-60	1000, feed thru
C-17	1000, feed thru	C-61	330
C-18	330	C-62	1000
C-19	1000	C-63	1000, feed thru
C-20	1000, feed thru	C-64	1000
C-21	1000	C-65	1000, feed thru
C-22	1000, feed thru	C-66	330
C-23	330	C-67	1000
C-24	1000	C-68	1000, feed thru
C-25	1000, feed thru	C-69	330
C-26	330	C-70	1000
C-27	1000	C-71	1000, feed thru
C-28	1000, feed thru	C-72	330
C-29	330	C-73	1000
C-30	1000	C-74	1000, feed thru
C-31	1000, feed thru	C-75	1000, feed thru
C-32	1000, feed thru	C-76	82
C-33	82	C-77	not used
C-34	1000	C-78	1000
C-35	1000	C-79	1000
C-36	1000 feed thru	C-80	1000 feed thru
C-37	" " "	C-81	" " "
C-38	" " "	C-82	" " "
C-39	" " "	C-83	" " "
C-40	" " "	C-84	" " "
C-41	" " "	C-85	" " "
C-42	" " "	C-86	" " "
C-43	" " "	C-87	1000
C-44	1000, feed thru	C-88	500

A. I-F STRIP (Continued)

3. Coils.

L-1 12µh air core
L-2 special slug-tuned
L-3 " " "
L-4 " " "
L-5 " " "
L-6 " " "
L-7 " " "
L-8 " " "
L-9 " " "
L-10 air core
L-11 12µh air core
L-12 air core filament suppressor
L-13 air core filament suppressor
L-14 air core
L-15 special slug-tuned
L-16 special slug-tuned
L-17 special slug-tuned
L-18 " " "
L-19 " " "
L-20 " " "
L-21 " " "
L-22 " " "
L-23 air core
L-24 12µh air core
L-25 air core filament suppressor
L-26 air core filament suppressor
L-27 air core filament suppressor
L-28 special slug-tuned
L-29 special slug-tuned
L-30 12µh air core

4. Connectors.

J-1 Jones P-310AB
J-2 UG-262/U IF INPUT
J-3 UG-185/U TEST SIGNAL
J-4 UG-262/U 60-Mc
J-5 UG-262/U 30-Mc
J-6 Not used
J-7 UG-185/U 30-Mc in.
J-8 UG-185/U 60-Mc in.
J-9 UG-185/U Attenuator input
J-10 UG-535/U Attenuator output
J-11 UG-262/U I-F output
P-1 Jones S-310 CCT
P-2 UG-88/U
P-3 UG-88/U
P-4 Not used
P-5 Not used
P-6 Not used
P-7 UG-88/U
P-8 UG-88/U
P-9 UG-88/U
P-10 UG-260/U
P-11 UG-260/U

5. Switches.

S-1 DPDT Carling IF AMPL
S-2 DPDT " 1DB
S-3 DPDT " 2DB
S-4 DPDT " 3DB
S-5 DPDT " 5DB
S-6 DPDT " 10DB

B. CONTROL CIRCUITS.

1. Resistors. (Unless otherwise specified, all components are fixed composition, 1/2 watt, 10% tolerance resistors.)

R-301 2K, Pot, Time delay Adj.
R-302 350 Pot, COARSE NOISE OUTPUT
R-303 60 Pot, FINE NOISE OUTPUT
R-304 100 Pot High Hd A Preset
R-305 200 Pot Mid
R-306 60 Pot Low
R-307 200 Pot Low Hd B Preset
R-308 100 Pot High
R-309 200 Pot Low Hd C Preset
R-310 100 Pot High
R-311 2, 10W Pot Fil Current
R-312 3, 10W
R-313 5, 10W Pot Fil Current
R-314 4, 10W
R-315 1, 10W
R-316 1, 5W Pot Fil Current
R-317 500 Pot Meter Shunt Hd A
R-318 500 Pot Meter Shunt Hd A
R-319 5 Pot Meter Shunt, Hd B
R-320 12
R-321 5 Pot Meter Shunt, Hd B
R-322 2.7, 1W
R-323 18
R-324 5 Pot Meter Shunt Hd C
R-325 5 Pot Meter Shunt Hd C
R-326 313
R-327 18.9
R-328 313
R-329 10, 2W
R-330 10, 2W
R-331 10, 2W
R-332 10, 2W
R-333 1000, 50W
R-334 750, 25W Pot Fil Current Set
R-335 390K
R-336 500, 50W
R-337 350 25W Pot Noise O.P. Gas
R-338 5, Pot
R-339 51K
R-340 50K Pot +140V Adj.
R-341 33K
R-342 6.8K
R-343 500, 5W
R-344 200
R-345 47K, 2W
R-346 22K, 2W

2. Capacitors.

C-301 2000µf 15V electrolytic
C-302 40µf 450V electrolytic
C-303 a. 40µf 450V electrolytic
b. 40µf 450V electrolytic
C-304 .01µf disc ceramic
C-305 20µf 250V electrolytic
C-306 .01µf disc ceramic
C-307 .01µf disc ceramic
C-308 0.1µf 400V Met. paper
C-309 0.1µf 400V Met. paper

3. Connectors.

J-301 UG-185/U 3-DB Atten. input
J-302 Jones S-312AB NOISE DIODES
J-303 Jones S-308AB GAS TUBES
P-301 Jones P-308CCT 200B P-S
P-302 Jones S-304CCT -200V P-S
P-303 UG-88/U 3-DB Atten. output

4. Switches.

S-301 SPST Carling POWER ON
S-302 Momentary DPDT 3A/125V NOISE DIODES START
S-303 Rotary eight-wafer ten-position NOISE SOURCE
S-304 4PDT Pushbutton OAK 3DB PUSH
S-305 SPST Carling GAS TUBES ON
S-306 Momentary DPDT 3A/125V GAS TUBES START

5. Miscellaneous

D-301 Selenium rectifier, FT & R 139CI AX1
D-302
D-303 Selenium rectifier, FT & R 1010
D-304
K-301 Thermal Time Delay Relay, GV RF type 30
K-302 Relay, DPDT, Allied B06A
L-301 Choke, 2H at 200 ma d-c, Standard C-2325
L-302 Ballast, G-E #58G690
M-301 Ammeter, 1-200µa
T-301 Transformer iron-core Sola #30804
T-302 Transformer
T-303 Transformer, 1:1 isolation; Freed IT2

C. NOISE DIODE HEADS.

NOTE: Components with 400-series numbers are located in noise head A; 500-series, Head B; 600-series, Head C.

1. Resistors. (Unless otherwise specified all components are fixed, composition, 10% tolerance, 1/2 watt resistors).

R-401	51	R-603	100
R-402	345	R-604	100
R-501	10	R-605	62
R-502	10	R-606	62
R-503	100	R-607	22
R-504	50	R-608	300
R-601	300	R-609	300
R-602	300	R-610	22

2. Capacitors. (Unless otherwise indicated, all values in μμf).

C-401	1500 ceramicon	C-602	.02μf disc ceramicon
C-402	1500 ceramicon	C-603	1000 feed thru
C-403	1500 ceramicon	C-604	.02μf disc ceramicon
C-404	1500 ceramicon	C-605	.02μf disc ceramicon
C-501	1000 feed thru	C-606	500 button Ag-Mica
C-502	.02μf disc ceramicon	C-607	500 button Ag-Mica
C-503	5000 disc ceramicon	C-608	1000, feed thru
C-504	5000 disc ceramicon	C-609	.02μf disc ceramicon
C-505	1000 feed thru	C-610	.01μf feed thru
C-601	1000 feed thru	C-611	.01μf feed thru

3. Connectors.

J-401	UG-625/U	P-401	Jones P-312 CCT
J-402	UG-625/U	P-402	AN-3106-14S-2P
J-403	AN-3101B-14S-2S	P-501	Jones P-312 CCT
J-501	UG-58/U	P-601	Jones P-312 CCT
J-601	UG-625/U	P-701	Jones P-308 CCT
J-602	UG-625/U	P-801	Jones P-308 CCT

4. Coils.

L-401	3.3μh Fil choke	Jeffers	L-601 RF Choke, special
L-402	" " "	"	L-602 Filament choke, special
L-403	" " "	"	L-603 Not used
L-404	" " "	"	L-604 thru L-611 r-f choke special

L-501 Fila choke special bifilar

D. MINUS 200-VOLT SUPPLY.

1. Resistors. (Unless otherwise specified, all components are fixed composition, 1/2 watt, 10% tolerance resistors):

R-901 6K 10W
R-902 2.5K 5W
R-903 100K, 1/2 watt
R-904 100K, 1/2 watt

2. Capacitors.

C-901 2µf, 450V electrolytic
C-902 40µf 450V electrolytic
C-30 .01µf 600V electrolytic

3. Tubes.

V-901 6X4
V-902 0B2
V-903 0B2

4. Miscellaneous.

P-901 Jones P-304 CCT
T-901 Transformer KP-51

E. MODEL 200B POWER SUPPLY.

1. Resistors. (Unless otherwise specified, all components are fixed composition, 1 watt, 10% tolerance resistors):

R-1001 330K
R-1002 100
R-1003 33
R-1004 100
R-1005 100
R-1006 33
R-1007 100
R-1008 100
R-1009 33
R-1010 100
R-1011 100
R-1012 33
R-1013 100
R-1014 2.2M, 1/2W
R-1015 100
R-1016 680K, 1/2W
R-1017 250K Pot., B+ Adj.
R 1018 33K
R-1019 47K, 2W
R-1020 270K

2. Capacitors. (Unless otherwise indicated, all values are in µf).

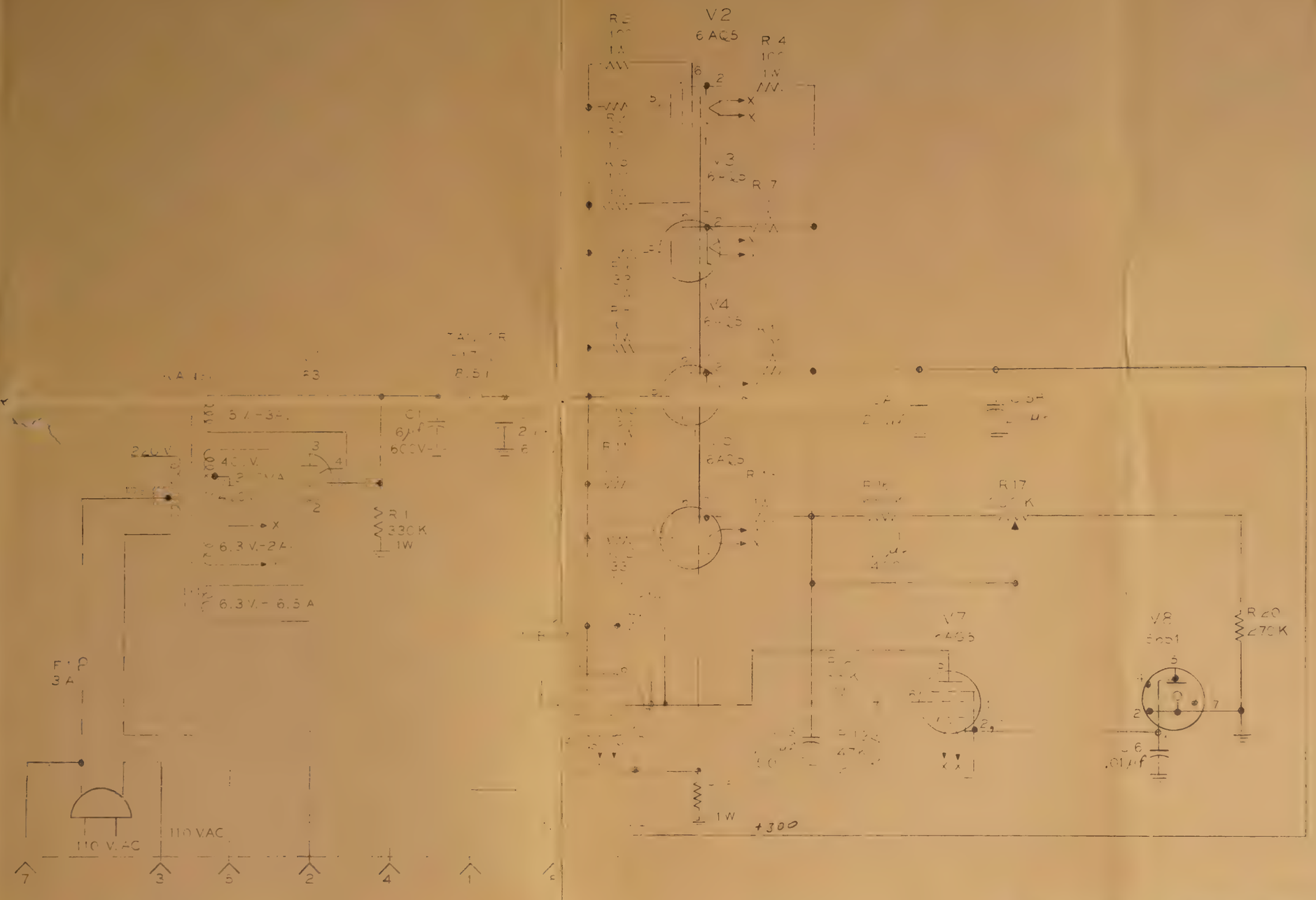
C-1001 6µf, 600V electrolytic
C-1002 2µf, 600V electrolytic
C-1003 .01µf, 500V
C-1004 0.1µf, 400V
C-1005 a. 20µf electrolytic
b. 20µf electrolytic
C-1006 .01µf

3. Tubes.

V-1001 83
V-1002 6AQ5
V-1003 "
V-1004 "
V-1005 6AQ5
V-1006 6AQ5
V-1007 6AG5
V-1008 5651

4. Miscellaneous.

F-1001 Fuse, 3A; 250V
L-1001 Choke, 8.5h, Stancor C-1721
J-1001 Jones, S-308AB
T-1001 Transformer, HiV, KA2520



SCHEMATIC MODEL 200 B POWER SUPPLY

KAY ELECTRIC CO., PINE BROOK, N. J.

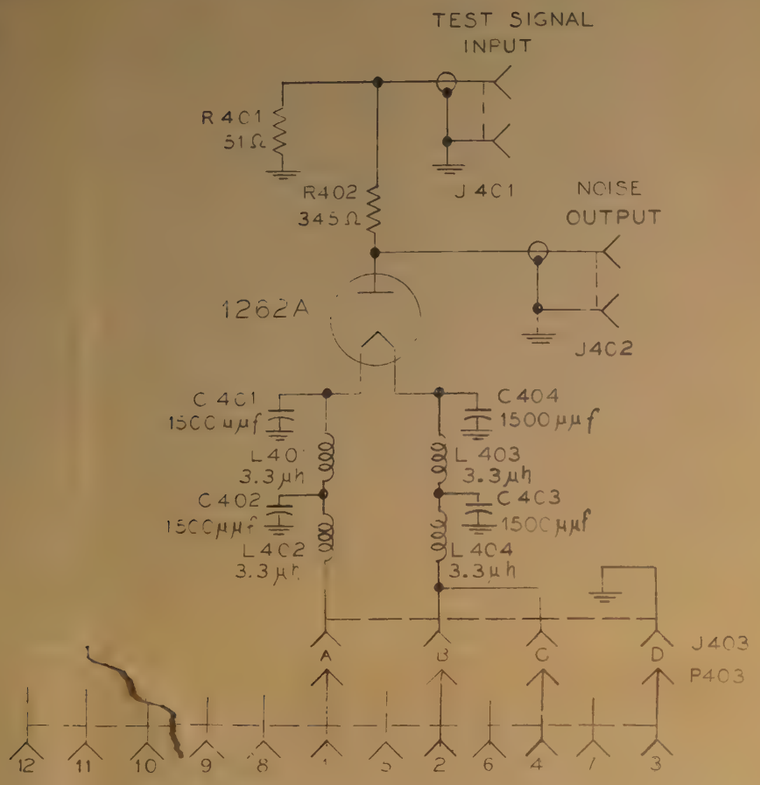
MAT.	FINISH:	SCALE:
DIMENSIONS TOLERANCES UNLESS OTHERWISE SPECIFIED: DECIMAL DIMENSIONS ± .002 FRACTIONAL DIMENSIONS ± .008		

CHANGE	DATE	APP.
"A" Transformer No. KA2520 - Choke No. 17B1 ECO No.	11-3-55	DFA

DWN. BY AWP DATE 6-27-55

APP. BY DFA DATE 6-27-55

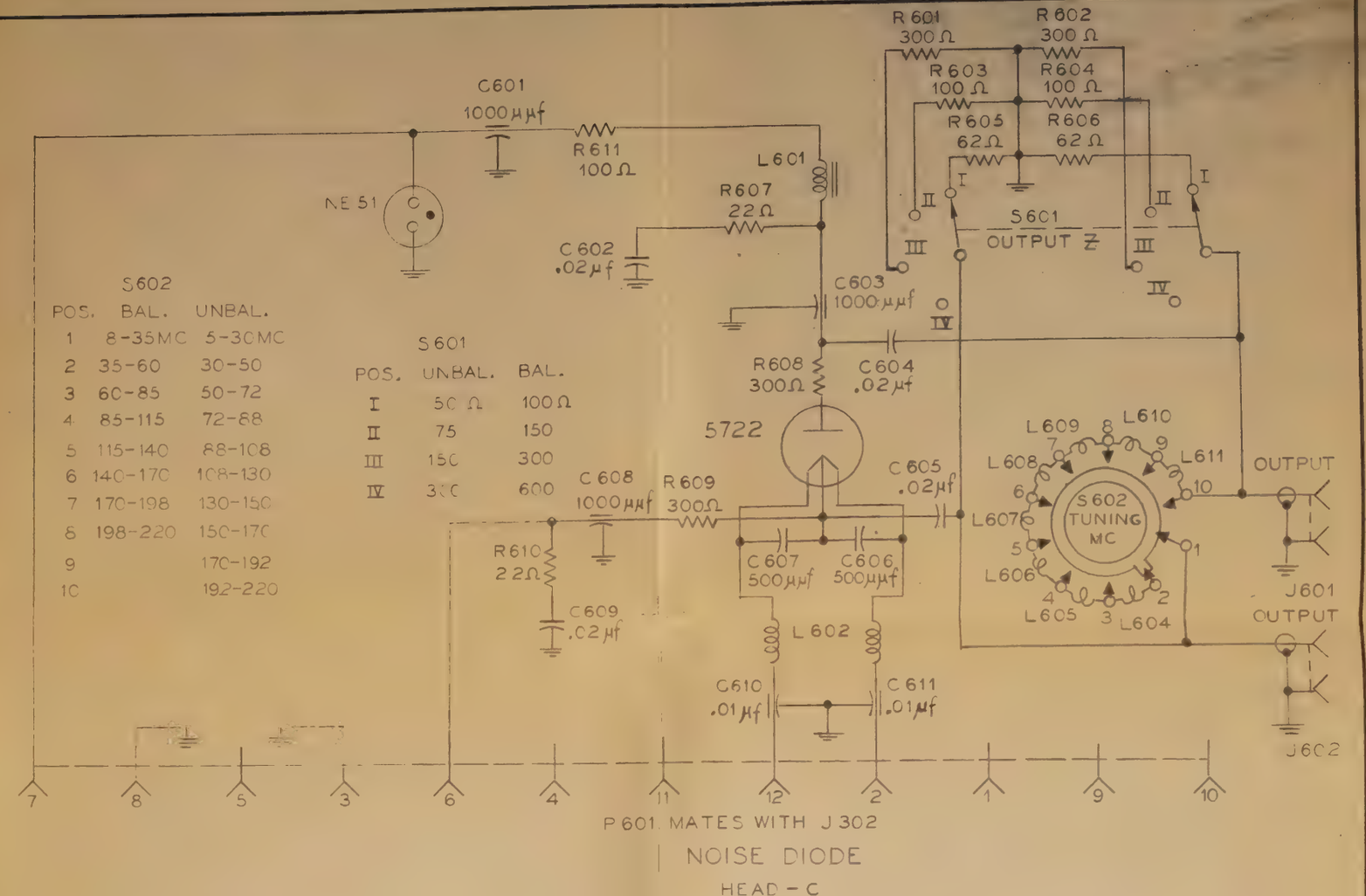
DWG. NO. KC 4509A



P401 MATES WITH J302

NOISE DIODE

HEAD - A



S602

POS.	BAL.	UNBAL.
1	8-35MC	5-30MC
2	35-60	30-50
3	60-85	50-72
4	85-115	72-88
5	115-140	88-108
6	140-170	108-130
7	170-198	130-150
8	198-220	150-170
9		170-192
10		192-220

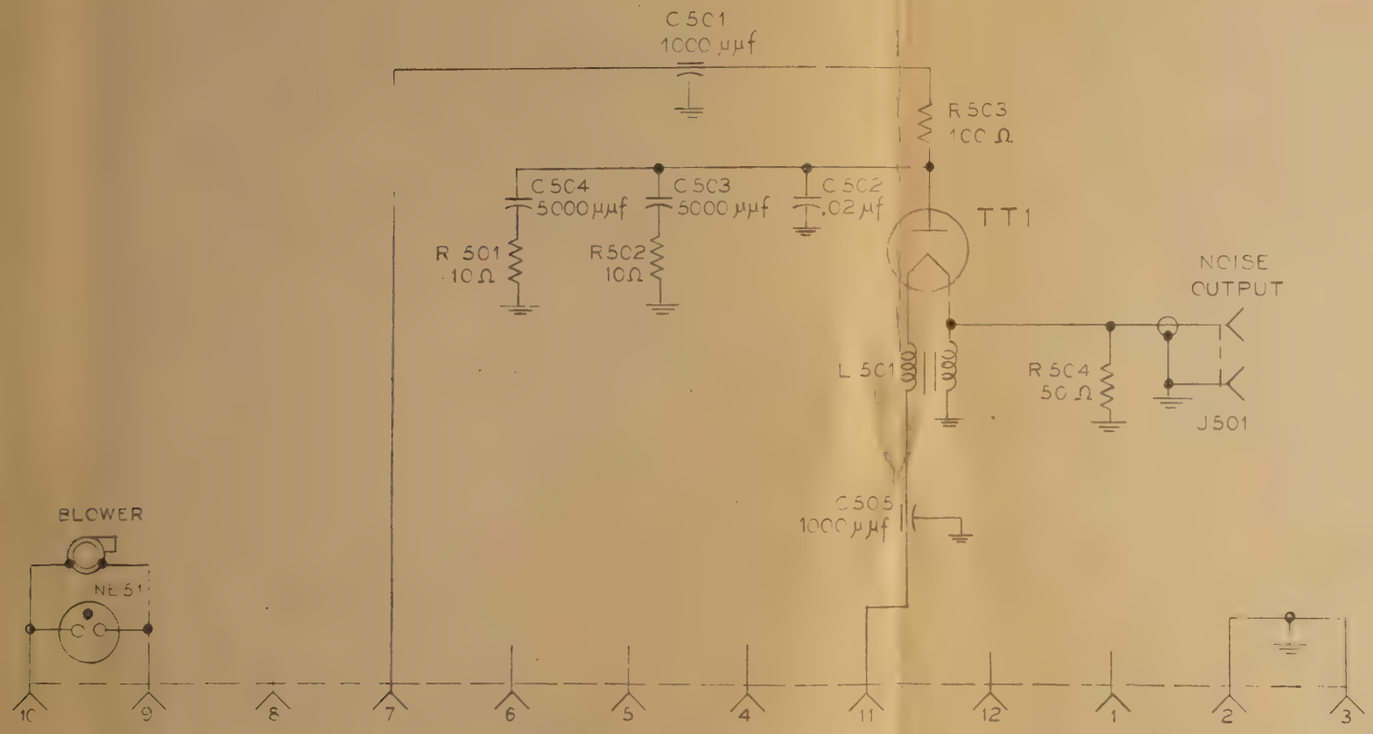
S601

POS.	UNBAL.	BAL.
I	50 Ω	100 Ω
II	75	150
III	150	300
IV	300	600

P601 MATES WITH J302

NOISE DIODE

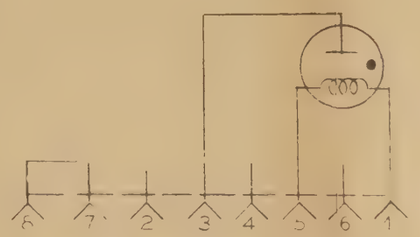
HEAD - C



P501 MATES WITH J302

NOISE DIODE

HEAD - B

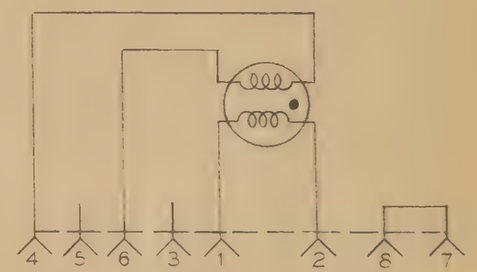


P701 MATES WITH J303

ARGON

TUBE	WAVEGUIDE
TD10	RG 49/U
	RG 50/U
TD11	RG 51/U
	RG 52/U
TD13	RG 53/U
	RG 91/U

GAS TUBES



P801 MATES WITH J303

FLUORESCENT

TUBE	WAVEGUIDE
T5-8W	RG 49/U
	RG 50/U
	RG 51/U
	RG 52/U
T8-15W	RG 48/U
	RG 69/U

SCHEMATICS NOISE DIODE HEADS & GAS TUBES RADA-NODE

MAT. | FINISH: | SCALE:

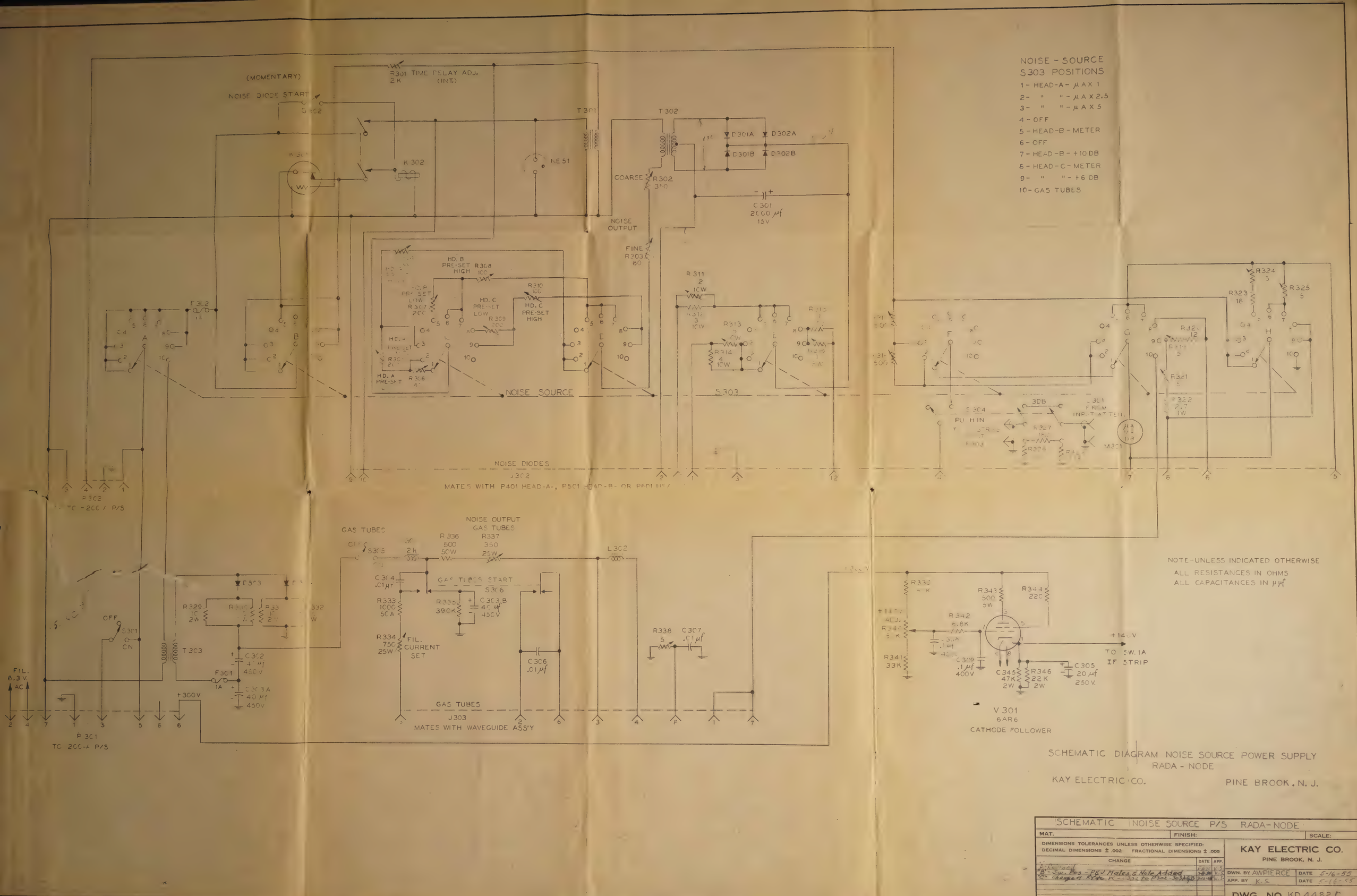
DIMENSIONS TOLERANCES UNLESS OTHERWISE SPECIFIED:
DECIMAL DIMENSIONS ± .002 FRACTIONAL DIMENSIONS ± .005

CHANGE	DATE	APP.
"3" Retain & N.S. 1 changed	7-7-55	K.S.

KAY ELECTRIC CO.
PINE BROOK, N. J.

DWN. BY AWPIERCE DATE 7-7-55
APP. BY K. S. DATE 7-7-55

DWG. NO. KC 4483 B

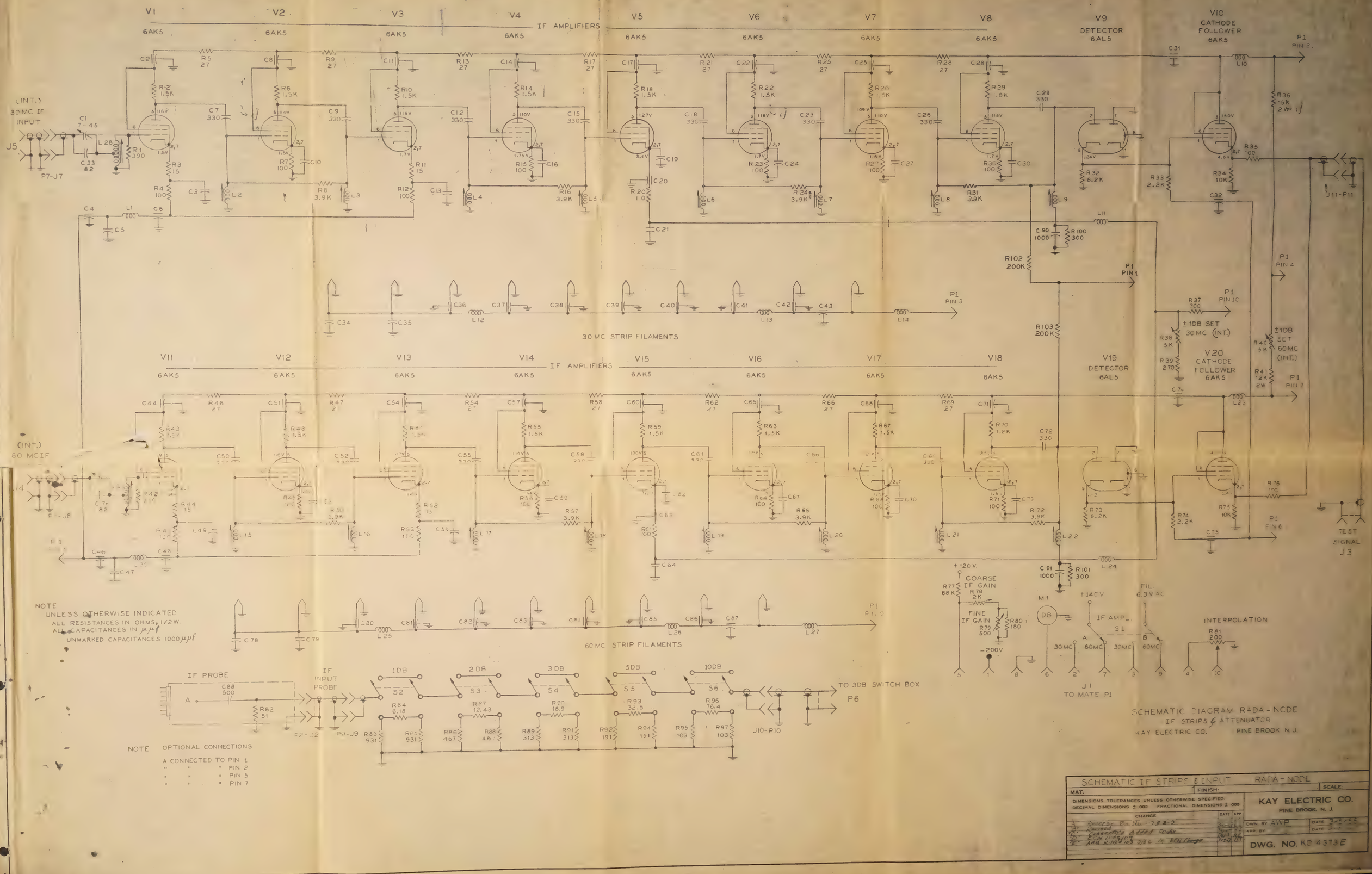


NOTE - UNLESS INDICATED OTHERWISE
ALL RESISTANCES IN OHMS
ALL CAPACITANCES IN μμf

SCHEMATIC DIAGRAM NOISE SOURCE POWER SUPPLY
RADA - NODE

KAY ELECTRIC CO. PINE BROOK, N. J.

SCHEMATIC	NOISE SOURCE P/S RADA-NODE	
MAT.	FINISH:	SCALE:
DIMENSIONS TOLERANCES UNLESS OTHERWISE SPECIFIED: DECIMAL DIMENSIONS ± .002 FRACTIONAL DIMENSIONS ± .005	KAY ELECTRIC CO. PINE BROOK, N. J.	
CHANGE	DATE / APP.	
A - Original	5-16-55 K.S.	
B - Sw. Pos - P&J Mates & Note Added	7-5-55 K.S.	DWN. BY AW PIERCE DATE 5-16-55
C - Changed Ref. R-302 to R302-303 & P5	11-4-55 K.S.	APP. BY K.S. DATE 5-16-55
		DWG. NO. KD 4482 C


V1 V2 V3 V4 IF AMPLIFIERS V5 V6 V7 V8 V9 DETECTOR V10 CATHODE FOLLOWER
6AK5 6AK5 6AK5 6AK5 6AK5 6AK5 6AK5 6AK5 6AL5 6AK5
(INT.) 30 MC IF INPUT
J5
P7-J7
C1 7-45
C33 82
L28
R1 390
C4 C5 C6 L1
C2 C8 C11 C14 C17 C22 C25 C28
R5 27 R9 27 R13 27 R17 27 R21 27 R25 27 R28 27
R2 1.5K R6 1.5K R10 1.5K R14 1.5K R18 1.5K R22 1.5K R26 1.5K R29 1.8K
C7 330 C9 330 C12 330 C15 330 C18 330 C23 330 C26 330 C29 330
R3 15 R4 100 R7 100 R11 15 R12 100 R15 100 R20 100 R23 100 R27 100 R30 100
C3 C10 C13 C16 C19 C20 C21 C24 C27 C30
R8 3.9K R16 3.9K R24 3.9K R31 3.9K
L2 L3 L4 L5 L6 L7 L8 L9
C31 L10 L11
R32 8.2K R33 2.2K R34 10K R35 100 R36 1.5K 2W
C32
C90 1000 R100 300
R102 200K R103 200K
P1 PIN 2 P1 PIN 3 P1 PIN 4 P1 PIN 1 P1 PIN 10 P1 PIN 7 P1 PIN 6
J11-P11
C34 C35 C36 C37 C38 C39 C40 C41 C42 C43 L12 L13 L14
30 MC STRIP FILAMENTS
±1DB SET 30 MC (INT.)
R37 300 R38 5K R39 270
±1DB SET 60 MC (INT.)
R40 5K R41 12K 2W
V20 CATHODE FOLLOWER 6AK5
V19 DETECTOR 6AL5
C72 330 C73 C74 L23
R73 8.2K R74 2.2K R75 10K R76 100 C75
TEST SIGNAL J3
V11 V12 V13 V14 IF AMPLIFIERS V15 V16 V17 V18
6AK5 6AK5 6AK5 6AK5 6AK5 6AK5 6AK5 6AK5
(INT.) 60 MC IF
J4
P2-J8
C7 82
C44 C51 C54 C57 C60 C65 C68 C71
R46 27 R47 27 R54 27 R58 27 R62 27 R66 27 R69 27
R43 1.5K R48 1.5K R55 1.5K R59 1.5K R63 1.5K R67 1.5K R70 1.8K
C50 330 C52 330 C55 330 C58 330 C61 330 C66 330
R42 330 R44 15 R45 100 R49 3.9K R50 100 R52 15 R53 100 R56 100 R57 3.9K R60 100 R64 100 R65 3.9K R68 100 R71 100 R72 3.9K
C49 C56 C59 C62 C63 C67 C70 C73
R41 100
C46 C47 C48 C64
L15 L16 L17 L18 L19 L20 L21 L22
C91 1000 R101 300 L24
P1
NOTE
UNLESS OTHERWISE INDICATED
ALL RESISTANCES IN OHMS, 1/2W.
ALL CAPACITANCES IN μμf
UNMARKED CAPACITANCES 1000 μμf
C78 C79 C80 C81 C82 C83 C84 C85 C86 C87 L25 L26 L27
60 MC STRIP FILAMENTS
P1 P1.9
IF PROBE
C88 500
R82 51
P2-J2
IF INPUT PROBE
P1-J9
1DB 2DB 3DB 5DB 10DB
S2 S3 S4 S5 S6
R83 931 R84 6.18 R85 931 R86 467 R87 12.43 R88 467 R89 313 R90 18.9 R91 313 R92 191 R93 32.5 R94 191 R95 103 R96 76.4 R97 103
J10-P10
TO 3DB SWITCH BOX P6
NOTE OPTIONAL CONNECTIONS
A CONNECTED TO PIN 1
" " " PIN 2
" " " PIN 5
" " " PIN 7
+120 V.
COARSE IF GAIN R77 68K R78 2K
FINE IF GAIN R79 500 R80 180
-200V
M1 DB
+14 CV
IF AMPL. S1
A 30MC 60MC B 30MC 60MC
FIL. 6.3 V AC
INTERPOLATION R81 200
J1 TO MATE P1
SCHEMATIC DIAGRAM RADA-NODE
IF STRIPS & ATTENUATOR
KAY ELECTRIC CO. PINE BROOK N.J.
SCHEMATIC IF STRIPS & INPUT RADA-NODE
MAT. FINISH: SCALE:
DIMENSIONS TOLERANCES UNLESS OTHERWISE SPECIFIED:
DECIMAL DIMENSIONS ± .002 FRACTIONAL DIMENSIONS ± 005
CHANGE DATE APP
A Revised per No. 1383
B Revised
C Corrections Added Coils
D ECN 11-1010
E ECN 11-1010
F ECN 11-1010
KAY ELECTRIC CO. PINE BROOK, N. J.
DWN. BY AWP DATE 3-25-52
APP. BY DATE
DWG. NO. KD 4373 E

Microwave Mega-Nodes

KAY ELECTRIC CO.

KAY ELECTRIC COMPANY

Microwave Mega-Node

INSTRUCTION MANUAL

Model 521 A

KAY ELECTRIC CO. • PINE BROOK, N. J.

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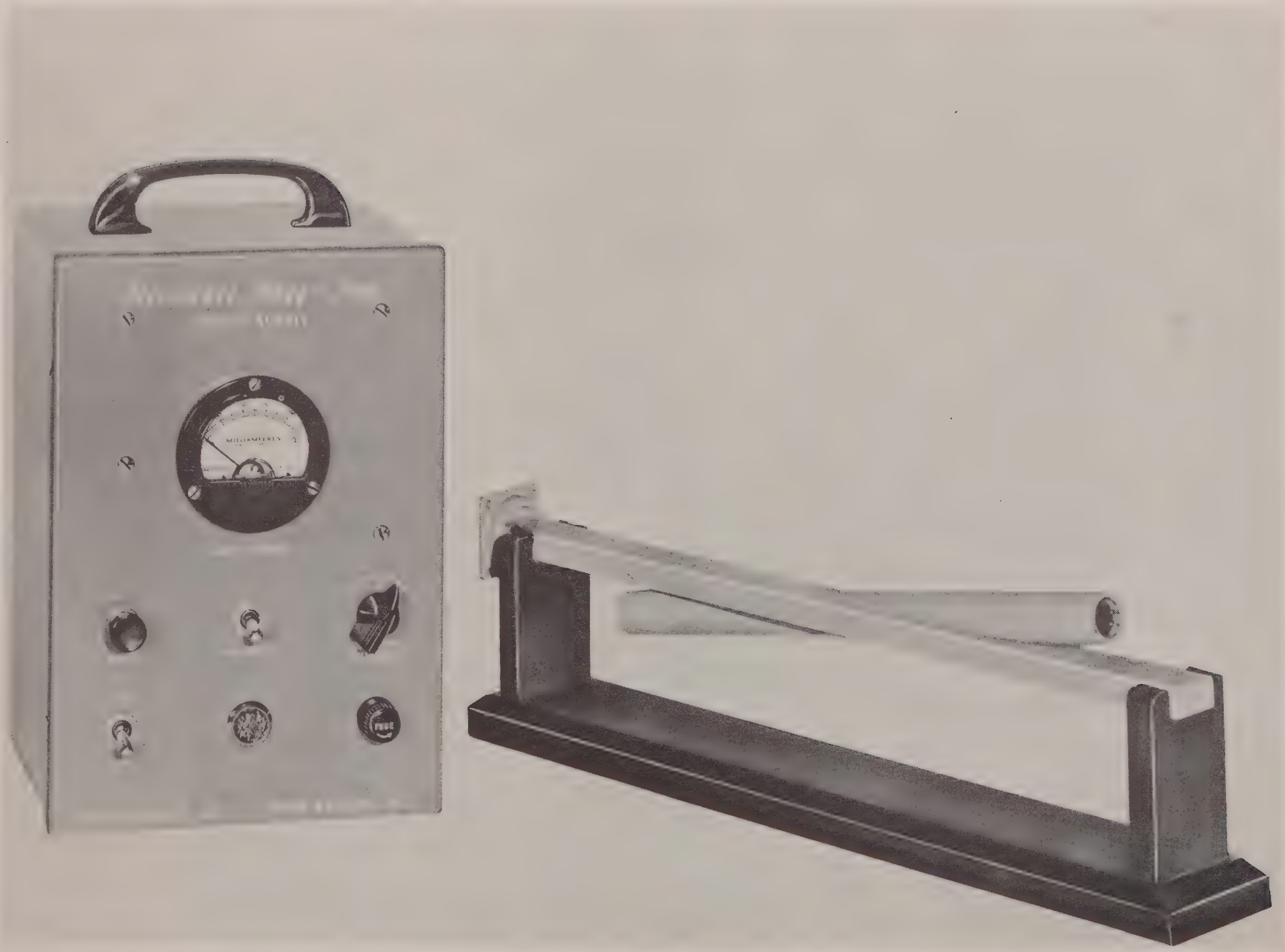


Figure 1, **MICROWAVE MEGA-NODE**

SECTION I
GENERAL DESCRIPTION

A. PURPOSE.

The **MICROWAVE MEGA-NODES** constitute a series of eight, random-noise generators, covering the frequency range 1120 to 26,500 Mc. They are designed to be used in noise figure calculations, signal calibration measurements, receiver gain tests, and/or overall performance checks. Any of the above information may be obtained by comparing the noise output of the system under test with the known noise level introduced by the **MICROWAVE MEGA-NODE**.

B. DESCRIPTION.

Each of the **MICROWAVE MEGA-NODES** includes a power supply unit and a separate waveguide assembly. The waveguide assembly consists of a standard JAN waveguide, each end terminated in a JAN flange. The noise source consists of either a conventional fluorescent tube or an argon gas tube. In each of the **MICROWAVE MEGA-NODES** except the RG-69/U, the noise tube is mounted at an acute angle through the middle of the waveguide.

C. SPECIFICATIONS.

1. Operating Range and VSWR.

JAN WAVEGUIDE NUMBER	LAMP SIZE		RECOMMENDED RANGE, $TE_{0,2}$ MODE	VSWR
	FLUORESCENT	ARGON		
RG-69/U**	T-8, 30 WATT	-----	1.12-1.7 KMC	< 1.3:1
RG-69/U+	GE-F14T12W, 14 WATT	TD-21	1.2-1.4 KMC	1.07:1 MAX.
RG-104/U**	T-8, 30 WATT	-----	1.7-2.2 KMC	< 1.3:1
RG-112/U**	T-8, 30 WATT	-----	2.2-3.3 KMC	< 1.2:1
RG-48/U+	T-8, 15 WATT	TD-12	2.6-3.95 KMC	F > 2.79, 1.1:1; 1.2:1 MAX.
RG-49/U+	T-5, 8 WATT	TD-10	3.95-5.85 KMC	< 1.1:1
RG-50/U+	T-5, 8 WATT	TD-10	5.85-8.2 KMC	F < 7.5, 1.1:1; 1.2:1 MAX.
RG-51/U+	T-5, 8 WATT	TD-11	7.05-10.0 KMC	< 1.1:1
RG-52/U+	T-5, 8 WATT	TD-11	8.2-12.4 KMC	< 1.1:1
RG-91/U*	----------	TD-13	12.4-18.0 KMC	MEAN < 1.1:1; MAX. 1.2:1
RG-53/U*	----------	TD-13	18.025.5 KMC	MEAN < 1.1:1; MAX. 1.2:1

*MANUFACTURED WITH ARGON TUBES ONLY.
+AVAILABLE WITH EITHER ARGON OR FLUORESCENT TUBE.
**AVAILABLE WITH FLUORESCENT TUBE ONLY.

2. Mechanical Specifications.

WAVEGUIDE TYPE	FLANGE	WEIGHT POUNDS	DIMENSIONS INCHES
RG-69/U	UG-417/U	35	43 x 10½ x 9
RG-69/U	UG-417/U	11	6 x 6¾ x 17
RG-104/U	UG-435/U	35	43 x 8 x 7
RG-112/U	UG-553/U	30	40 x 7 x 6
RG-48/U	UG-214/U	11½	24 x 8¾ x 5½
RG-49/U	UG-149/U	5½	18¾ x 7½ x 4
RG-50/U	UG-344/U	3¾	17¾ x 6¼ x 3½
RG-51/U	UG-51/U	3	18¾ x 6¼ x 3
RG-52/U	UG-39/U	2¼	16 x 5¼ x 2¾
RG-91/U	UG-149/U	1½	13½ x 5¾ x 1½
RG-53/U	UG-425/U	1¼	14 x 4¾ x 2½

3. Noise Output Above Thermal Noise.

a. Fluorescent: 15.84 ±0.25db at 32 °C

b. Argon Gas: 15.28 ±0.1db

4. Power Requirements.

a. Fluorescent: 40W, 115V (±10%), 60 cps, a-c power input.

b. Argon Gas: 50W, 115V (±10%), 60 cps, a-c power input.

419

D. EQUIPMENT SUPPLIED.

1. Waveguide Assembly, including noise source and hardwood stand.

2. Power Supply Unit.

a. Fluorescent Models: RG-49/U, RG-50/U, RG-51/U, RG-52/U, RG-104/U (WR-430), RG-112/U (WR-240), RG-69/U, RG-48/U, RG-69/U (WR-650).

b. Argon Models: RG-49/U, RG-50/U, RG-51/U, RG-52/U, RG-53/U, RG-91/U, RG-69/U, RG-48/U.

3. Interconnecting Cables.

E. ADDITIONAL EQUIPMENT REQUIRED.

1. Power Indicator.

2. Precision IF attenuator or RF attenuator, for inserted attenuation methods.

SECTION II
INSTALLATION

A. GENERAL.

The **MICROWAVE MEGA-NODES** are designed for table-top operation and thus present no special installation problems. However, for optimum operation, the equipment should not be subjected to excessive moisture, temperature or vibration conditions. The installation should include provisions for connection to a 50W source of 115 volts (±10%), a-c power and to the equipment under test.

B. ASSEMBLY FOR USE.

1. After unpacking the equipment, inspect both the power supply and the waveguide assembly for obvious signs of damage.

2. Remove a-c power cord and tube cords from the rear of the power supply cabinet. Connect a-c plug *(P-1)* to 115 volt power source.

3. Remove tape from fluorescent or argon tube. Secure lamp connectors *(P-2 & P-3)* to each end of the tube.

4. Use flange supplied with the equipment to connect the waveguide to the circuit under test.

SECTION III
OPERATION

A. IDENTIFICATION OF CONTROLS.

1. **ON-OFF** Switch *(S-1)*. This DPDT switch controls the application of all a-c power to the **MICROWAVE MEGA-NODE**. When this switch is in the **ON** position, the adjacent red light comes on.

2. **START** Switch *(S-2)*. This momentary toggle switch is depressed only to start the **MICROWAVE MEGA-NODE**.

3. **CURRENT INCREASE** Control *(R-4)*. This potentiometer permits the operator to adjust the lamp current, as indicated on the meter, to prevent excessive tube dissipation.

4. **FUSE** *(F-1)*. This front-panel fuse, set in one side of the a-c line is used to protect the entire power supply and noise source assembly, it has a two-ampere rating.

5. **Meter.** This d-c milliammeter, calibrated from zero to 250 ma, is used in adjusting the tube current and the filament current to the proper level.

6. **Power Connections.** Each power supply is equipped with an a-c power cord, an output cable and two interconnecting cables which mate both with the output cable and the lamp terminals.

7. **Thermometer.** This accurately calibrated centigrade thermometer, permanently attached to the fluorescent tube waveguide assembly, is used to obtain an accurate and instantaneous indication of temperature variation. The fluorescent tube noise sources have a correction factor of -0.05db/°C above 32°C.

8. **Filament Current Control.** *(R-9)*. This internal potentiometer is used to set the argon tube filament current to the level specified in Section III, paragraph B-2, before energizing the noise source. The actual filament current value is read directly from the panel meter with the **START** switch depressed.

B. OPERATING INSTRUCTIONS.

1. Fluorescent Lamps.

a. Assemble equipment as described in Section II.

b. Turn power switch to **ON** position. The adjacent indicator lamp should light up immediately.

c. Depress **START** switch momentarily, then release; the lamp should light. If the lamp does not light depress **START** switch again and hold it down slightly longer. Repeat until lamp lights.

d. After the lamp lights, adjust the **INCREASE CURRENT** control until the milliammeter on the panel indicates the proper lamp current for the frequency or frequency spectrum in which you are interested. *(See figures 4 thru 8.)*

e. The noise source is now producing random noise across the entire useful frequency range of the waveguide.

f. If possible, allow a fifteen-minute warm-up period before using the noise source.

g. The fluorescent models have a temperature correction factor of 0.05db per degree Centigrade. Thus the output power in decibels. P_{out} is:

$$P_{out} = 15.84 - 0.05\ (T-32)$$

where T = the reading on the thermometer in degrees Centigrade. The thermometer reading should be checked *each time* a measurement is made.

h. If the **MICROWAVE MEGA-NODE** is to be used for noise figure measurements, follow the procedure outlined in paragraph B-3 or B-4 below.

2. Argon Tubes.

a. Proceed as with fluorescent lamps except that when **START** switch is initially depressed *R-9* (accessible from rear of cabinet) should be adjusted to limit the filament current (which is read on the panel meter) to values less than those tabulated below. When **START** switch is released and tube lights, **INCREASE CURRENT** control should be set to limit current through tube to values less than those tabulated below.

ARGON TUBE CHARACTERISTICS						
CHARACTERISTIC	TD-10	TD-11	TD-12	TD-13	TD-21	TD-24
Anode Current, MA DC	250	200	250	200	250	250
Filament Current, MA DC	170	170	300	170	300	170
Tube Dissipation, Watts	20	17	22	13	16	16
Tube Voltage Drop, V DC	80	85	90	65	65	65
Ambient Temperature Range	-40 to +165°F.					

3. Measurement of Noise Figure by Direct Comparison *(see figure 2a)*. In this method the calibration of the power indicator must be known and accurate.

a. Connect one end of the noise source waveguide to the receiver under test. Since the noise source waveguide is flanged at both ends, either end may be connected to the receiver (see Section IV, C and D).

b. Energize the **MICROWAVE MEGA-NODE** as previously described. Record the noise power of the circuit under test.

c. Remove the **MICROWAVE MEGA-NODE**. Connect the receiver input to a matched load. Record the reading on the power indicator.

d. The noise figure, F, may be computed from the formula:

$$F = \frac{38.29}{Y - 1}$$

where Y is the ratio of noise power obtained in step *b* (with the **MICROWAVE MEGA-NODE** in circuit) to that obtained in step *c* (matched load in circuit).

EXAMPLE

If the noise power output with the matched load on equals 0.05 watts and the noise power output with the **MICROWAVE MEGA-NODE** on equals 0.25 watts, then

$$Y = \frac{0.25}{0.05} = 5, \text{ and}$$

$$F = \frac{38.29}{5-1} = 9.57$$

CAUTION

Since noise contains components whose amplitude for brief periods may be much greater than rms noise power, great care should be taken to make certain that no overload occurs in the receiver, even at CW levels four times those of the noise levels encountered. It is also important to determine the law of the power indicator. Both the input-output characteristic of the receiver and the power indicator characteristic may be determined by measurements with a calibrated signal generator.

4. Measurement of Noise Figure by Inserted Attenuation Techniques *(see figures 2b and 2c)*. By utilizing either a precision IF attenuator, RF attenuator or both, this method eliminates the necessity for calibrating the receiver input-output characteristic. If the noise figure of the receiver under test is very low, full output power of the **MICROWAVE MEGA-NODE** may tend to overload any receiver whose output capabilities are limited.

Most receivers, however, can handle an output power twice that due to noise alone. If, then, an RF attenuator is placed between the **MICROWAVE MEGA-NODE** and the input of the receiver, the attenuation may be adjusted to produce an output power twice that available with the receiver input terminated in the normal (Z_o) input impedance. Thus Y, the ratio of output noise power with a **MEGA-NODE** connected to output noise power with the load connected, equals 2, and F the noise figure, then may be calculated from the formula,

$$F = (15.84 - \alpha) \text{ db (for argon lamps)}$$

If it is possible to insert a precise amount of attenuation in the IF amplifier (e.g., when the amplifier is composed of a preamplifier and main amplifier), this system of measurement becomes even simpler. The noise output of the receiver with Z_o input termination is adjusted to a convenient value. Then, with the **MICROWAVE MEGA-NODE** connected to the input through the RF attenuator, a 3db IF attenuation is inserted.

The RF attenuator is adjusted to return the power indicator to the *same* reading as before. The noise figure may then be calculated by the equation above. Since the power indicator is always operating at the same level and on the same kind of signal (noise) under both conditions of the measurement, overload effects are less important and very simple power indicators may be used. This is true, however, only if the 3db IF attenuation is introduced at a low level before overload occurs. Under these circumstances, simple measurement of IF detector rectified d-c voltage is a satisfactory indication of relative power output.

Another advantage of the above scheme is that normal RF attenuators may be adjusted to produce a high insertion loss. Consequently, with the lamp off and the attenuator at maximum (20db or more), the receiver will "see" an input termination sufficiently close to Z_o to eliminate the necessity of replacing the **MICROWAVE MEGA-NODE** with a Z_o load.

If only the IF attenuator is available, the above method may be employed with slight variation, retaining the "constant output" technique. Sufficient IF attenuation is inserted to bring the power output reading back to the original reading (with Z_o at room temperature at the input). When a fluorescent noise source is used, the noise figure then may be calculated from the following:

$$F = 15.84 - 10 \log_{10} (A-1) \text{ db},$$

where A is the inserted IF attenuation, expressed as a power ratio. For example, if the IF attenuation required is 6 db, that is, a power ratio of 4:1,

$$F = 15.84 - 10 \log_{10} (4-1)$$

$$= 15.84 - 4.77 = 11.07 \text{ db}.$$

Or, if only 1.5 db (1.41:1 power ratio) is required,

$$F = 15.84 - 10 \log_{10} (1.41-1)$$

$$= 15.84 + 3.87 = 19.71 \text{ db}.$$

By substituting a 15.28 value for the noise source output, the same formula may be applied to argon sources. Note that if the temperature of a fluorescent waveguide is not 32 °C, the temperature correction factor of -0.05db/°C must be added to all measurements.

Since the **MICROWAVE MEGA-NODES** have been designed to present a matched load to the line connecting them to the terminals of the receiver under test, no matching sections are required. If a matching device is needed to increase the efficiency of power transfer between the **MEGA-NODE** and receiver, it indicates a mismatch at the receiver terminals. The above definition of noise figure specifically rules out matching devices - it uses the

available power from the source and not the power transferred from source to receiver. If the receiver is to operate from Z_o source in the field, any loss of power in the transfer should be reflected in a poorer noise figure for the receiver.

It is tacitly assumed that the receiver has only a single response - without spurious responses such as images or harmonics. If spurious responses in the frequency range of the **MEGA-NODE** are present, the receiver will accept noise from the **MICROWAVE MEGA-NODE** at the spurious frequencies as well as on the desired channel. The accepted definition of noise employs the concept of the "useful channel bandwidth"[1,2]. If a noise generator is used in the noise figure measurement, a correction must be made to account for spurious receiver responses. If F is the noise figure as measured by the above method and F_t is the true noise figure, both expressed as power ratios, then

$$F_t = F\frac{B}{B_u},$$

where B is the total bandwidth, including spurious responses, and B_u is the useful channel bandwidth in cps. For example, when measuring a receiver which has a complete image (image response equal to the desired response), the ratio B/B_u is 2, and 3 db must be added to the measured noise figure to obtain the true noise figure.

SECTION IV
THEORY OF OPERATION

A. GENERAL THEORY OF NOISE SOURCES.

As indicated above, the noise sources used in the **MICROWAVE MEGA-NODES** are either commercial fluorescent lamps or argon lamps. In studying the utility of gas-filled lamps as a noise source, W. W. Mumford[3] has found that:

"In a gaseous discharge which is radiating light energy substantially monochromatically at a particular wavelength λ_m, the noise output at microwave frequencies is the same as that available from a black body which radiates its maximum energy at that wavelength."

The wavelength of maximum radiation for a black body may be determined from Wien's displacement law:

$$\lambda_m T = .289 \text{ deg. cm.}$$

Where T = temperature of the radiating body in degrees Kelvin and

λ_m = wavelength in cm.

It has been shown that radiation from the mercury vapor discharge in a standard fluorescent lamp is concentrated in a single spectral line ($\lambda_m = 2536.52\ 10^{-8}$cm). No more than about 2% of the total energy is radiated at other wavelengths. Using this wavelength in the Wien law above yields an equivalent lamp operating temperature (T_2) of 11,400°K. If Mumford's hypothesis is assumed to be true, this temperature represents a noise power of 15.84 db above the ideal available input noise power, kTB. (See discussion in paragraph B below.) Measurements by Mumford check this result closely.

Mumford has found that the noise output of a fluorescent lamp is substantially independent of the fluorescent coating and of current density, but is slightly affected by temperature. Since these measurements of absolute noise output power were made with a guide temperature of 17°C, a temperature correction factor must be added to the calculated noise output of all fluorescent models for waveguide temperatures of different value. Several separate studies have arrived at a closely similar temperature correction factor of 0.05 db per degree centigrade. Each fluorescent noise generator unit of the **MICROWAVE MEGA-NODES** is equipped with a permanently installed thermometer for rapid determination of the temperature correction factor.

B. THEORY OF NOISE FIGURE MEASUREMENTS.

The thermal noise energy of an ideal conductor (one that generates no noise of its own other than that due to thermal activity of the individual electrons) may be stated as a function of the absolute temperature (T) in degrees Kelvin and the bandwidth (B) of the generated noise in cps. The available noise power from an ideal signal generator may be formulated as:

$N = kTB$

where k = Boltzman's constant = 1.38×10^{-23}

However, in any circuit incorporating a vacuum tube (as contrasted to an ideal conductor), an additional amount of noise will be generated as a consequence of the greater randomness of electron travel in the tube. Then the noise figure of such

1. *Friis, H.T., Proceedings IRE, 1944, 419-422.*
2. *North, D.O., Proceedings IRE, 1945, 125-127.*
3. *Mumford, W. W., "A Broad-Band Microwave Noise Source", Bell Systems Technical Journal, October, 1949, 606-619.*

a circuit - a measure of the additional noise generated in an actual rather than an ideal circuit - may be defined as:

$$F = \frac{\text{available input signal-to-noise power ratio}}{\text{available output signal-to-noise power ratio}}$$

This basic equation can be modified in a number of ways, depending on the method used for making the particular measurement. For example, if a signal generator is used as a power source, the equation may be modified to:

$$F = S_g/mkTB$$

Where S_g is the maximum available signal power from the source in watts,

m is the ratio of signal power to noise power at the output of the circuit under test,

k is Boltzman's constant, 1.38×10^{-23}

T is the absolute temperature of the noise source in degrees Kelvin,

B is the bandwidth, over which the noise is observed, in cps.

If on the other hand, a hot-body noise source is used, the equation for noise figure may be written as:

$$F = \frac{([T_2/290]-1)}{(Y-1)}$$

where T_2 is the effective temperature in degrees K of the hot body and Y is the ratio of the noise power from network when the source is at T_2 to that when it is at room temperature.

Since T_2 for the lamps in use is 11,400°K,

$\frac{T_2}{290} - 1 = 38.29$ and

$$F = \frac{38.29}{Y-1}$$

C. WAVEGUIDE TERMINATIONS.

All of the waveguides of the **MICROWAVE MEGA-NODES** are terminated at both ends in a JAN cover flange. In the earlier models, one end of the RG-50/U, RG-51/U, RG-52/U and RG-69/U waveguides is terminated in a short circuit.

It has been determined that the RG-48/U and RG-49/U diodes may be inserted in a section of line without introducing serious discontinuities provided that the lamp is in position and is turned *off*. That is, if these units are connected between a receiver and a matched load, they will present a matched load to the receiver both at room temperature (with the lamp turned off) and at 11,400°K (with the lamp on). For this reason, flanges have been provided at both ends of these guides on both the earlier and later models.

In the six other guides mentioned above, the discontinuities introduced by the de-energized lamp are more serious and prohibit the use of this technique. The condition of the unused end is unimportant.

D. EFFECTS OF OPPOSITE END TERMINATIONS.

The available noise power supplied to the receiver of the noise source is substantially independent of the termination at the end of the guide not attached to the receiver. This condition is brought about by the insertion losses introduced in the guide by the ignited lamp. The magnitude of these losses is such that substantially none of the power radiated away from the receiver and reflected from the opposite termination (whether short or open) will appear at the receiver end of the guide. The termination of the unused end is, therefore, unimportant with the lamp ignited, except for the possible leakage problem encountered with poorly shielded receivers. It would be possible to obtain 15.84db noise from each end of the generator at the same time if desired.

E. VSWR.

A low VSWR (and the insertion loss mentioned above) are obtained by tilting the tube at an acute angle to the guide. Although the lamp at any one point is not matched to the guide impedance, the reflections from the various points of the lamp (there are several wavelengths of the lamp in the guide) cancel each other out to a large extent. The actual impedance match of the lamp to the guide is modified only slightly by the lamp current. Good results may be obtained over the entire recommended operating range of a given waveguide by operating the lamp at the recommended currents.

One of the problems encountered in the use of fluorescent lamps as noise sources has been the presence of audio oscillations across the lamp. No method of eliminating the oscillations by external circuits is known, and, as can be seen from the curve on VSWR, the impedance match of the lamp to the guide is affected slightly by lamp current. If, then, the current varies at an audio rate, the impedance of the generator will vary at the same rate, and the power delivered by the generator to a constant load will be similarly modulated. However, in the **MICROWAVE MEGA-NODES**, where the lamp is mounted at an acute angle to the waveguide, the variation of impedance with tube

current is extremely small. Since the actual tube current variations due to these oscillations are also small, the output impedance variation is almost negligible. It has not been possible to see other than random noise in the output of a receiver under test with these generators.

SECTION V
MAINTENANCE

A. GENERAL.

The simplicity of the **MICROWAVE MEGA-NODES** eliminates the necessity for any elaborate maintenance procedure. The most frequent troubles encountered with the **MICROWAVE MEGA-NODES** are leaky capacitors, defective rectifiers, or gas tube failures.

The **LAMP CURRENT** meter and the front-panel light are the two main indicators on the **MICROWAVE MEGA-NODE.**

If the indicator light does not come on when the **ON-OFF** switch is in the **ON** position, check the a-c supply, the front-panel **FUSE** *(F-1)*, and the indicator light. If **FUSE** *F-1* blows again on replacement, attempt to determine the cause of failure before replacing it a second time. Check particularly the electrolytic capacitor *(C-1)* and the rectifiers *(D-1 & D-2)*.

If the meter still reads zero when the **START** switch is depressed, check the operating procedure (Section III, paragraphs B-2 and B-3). If all potentiometer settings appear to be correct, check the fluorescent or argon lamp. To replace the lamp, remove the plugs from each end. The lamp may be removed by pressing against the lower end of the tube.

If the procedure outlined above does not correct the defect, de-energize the equipment and make the resistance checks on the power supply.

SECTION VI
PARTS LIST

RESISTORS.

R-1	10 OHMS, 2 WATTS
R-2	10 OHMS, 2 WATTS
R-3	10 OHMS, 2 WATTS
R-4	10 OHMS, 2 WATTS
R-5	560K
R-6	1K, 50 WATTS
R-7	350 OHMS, 50 WATTS, POT INCREASE
R-8	1K, 50 WATTS
R-9	750 OHMS, 25 WATTS, POT

CAPACITORS.

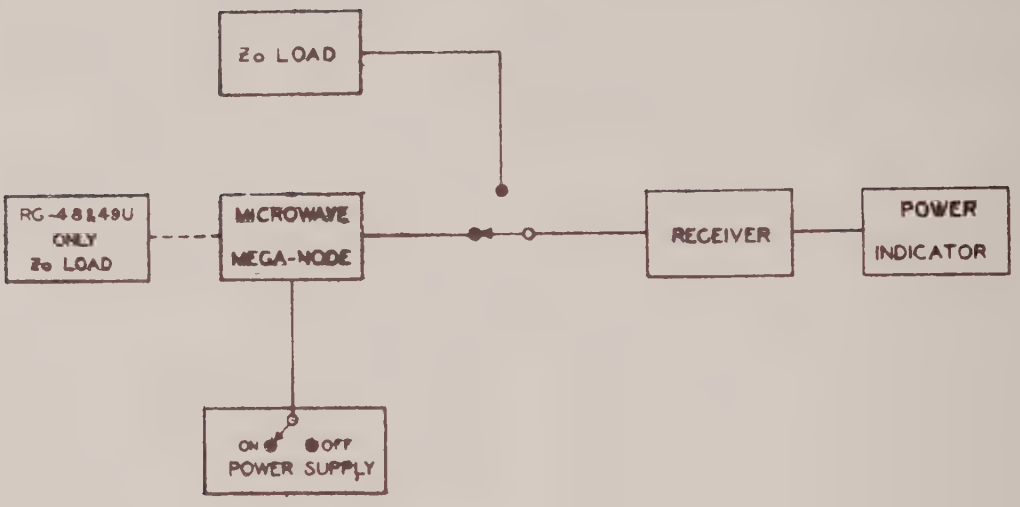
C-1*a*	40μF, 150V, ELECTROLYTIC
C-1*b*	40μF, 150V, ELECTROLYTIC
C-3	0.02μF, 500V, DISC CERAMIC
C-3	0.02μF, 500V, DISC CERAMIC
C-4	0.02μF, 500V, DISC CERAMIC
C-5	0.02μF, 500V, DISC CERAMIC

SWITCHES.

S-1	ON-OFF, DPST
S-2	START, DPST, MOMENTARY

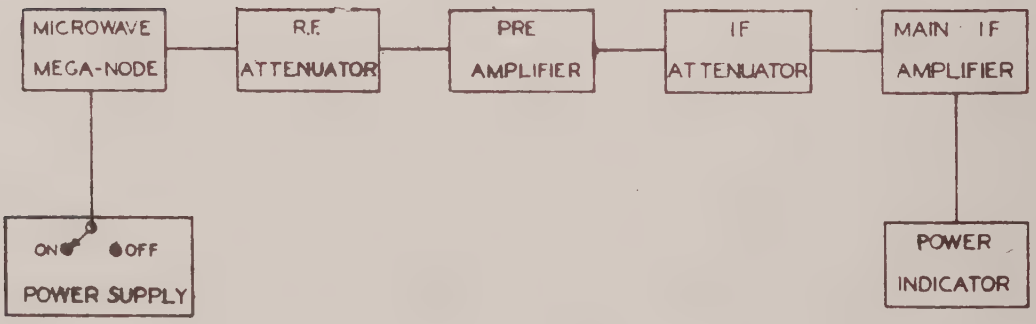
MISCELLANEOUS.

D-1	FT & R 1010 SELENIUM RECTIFIER
D-2	FT & R 1010 SELENIUM RECTIFIER
F-1	FUSE, 2 AMP
I-1	INDICATOR LIGHT, 120V, 3W, SCREW TYPE
L-1	COIL, 4H
M-1	METER, 0-300 MA MILLIAMMETER
V-1	TUBE, T-5, T-8, TD-11, TD-12 OR TD-13
TH-1	THERMOMETER



A.- BY DIRECT COMPARISON

B.- WITH INSERTED ATTENUATOR



C- WITH TWO INSERTED ATTENUATORS

Fig. 2 Interconnection Block Diagrams, Noise Figure Measurements

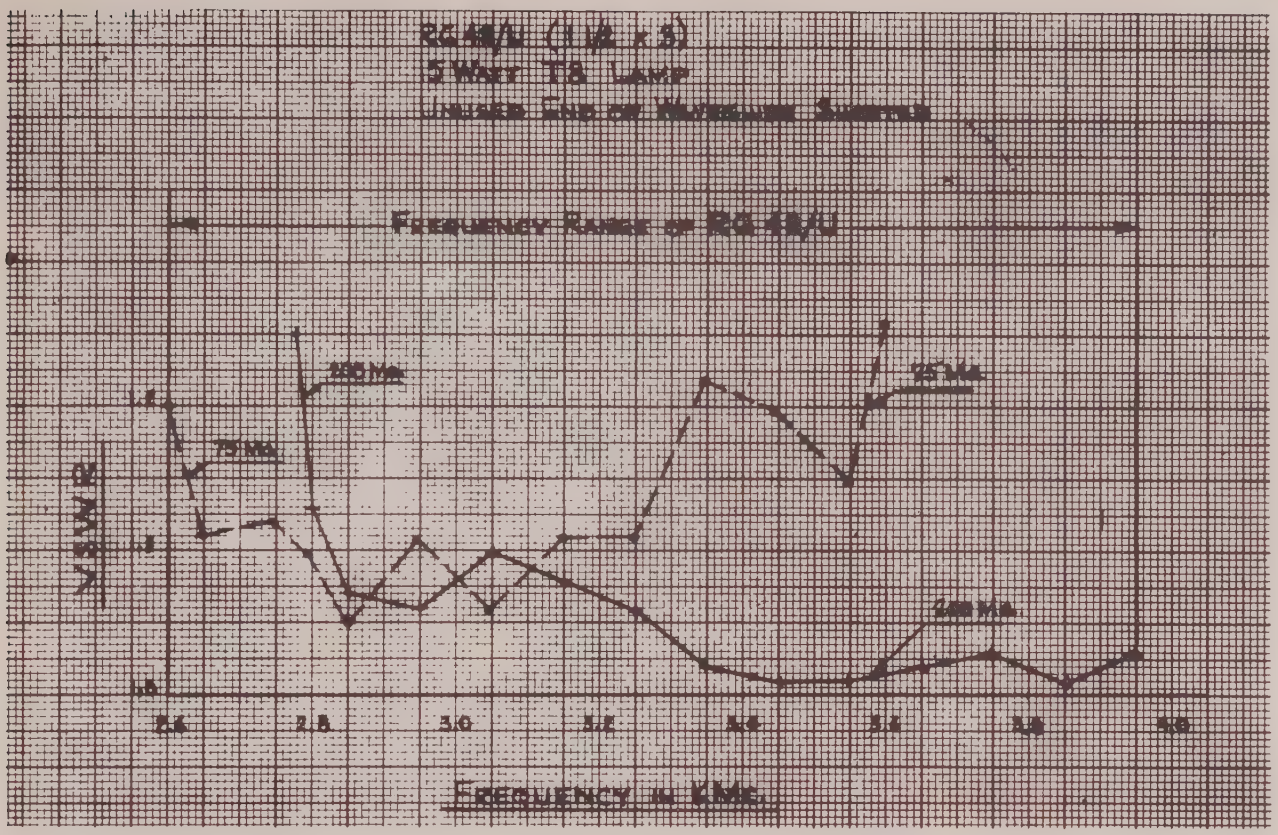


Fig. 3 **RG-48/U,** *VSWR versus Frequency*

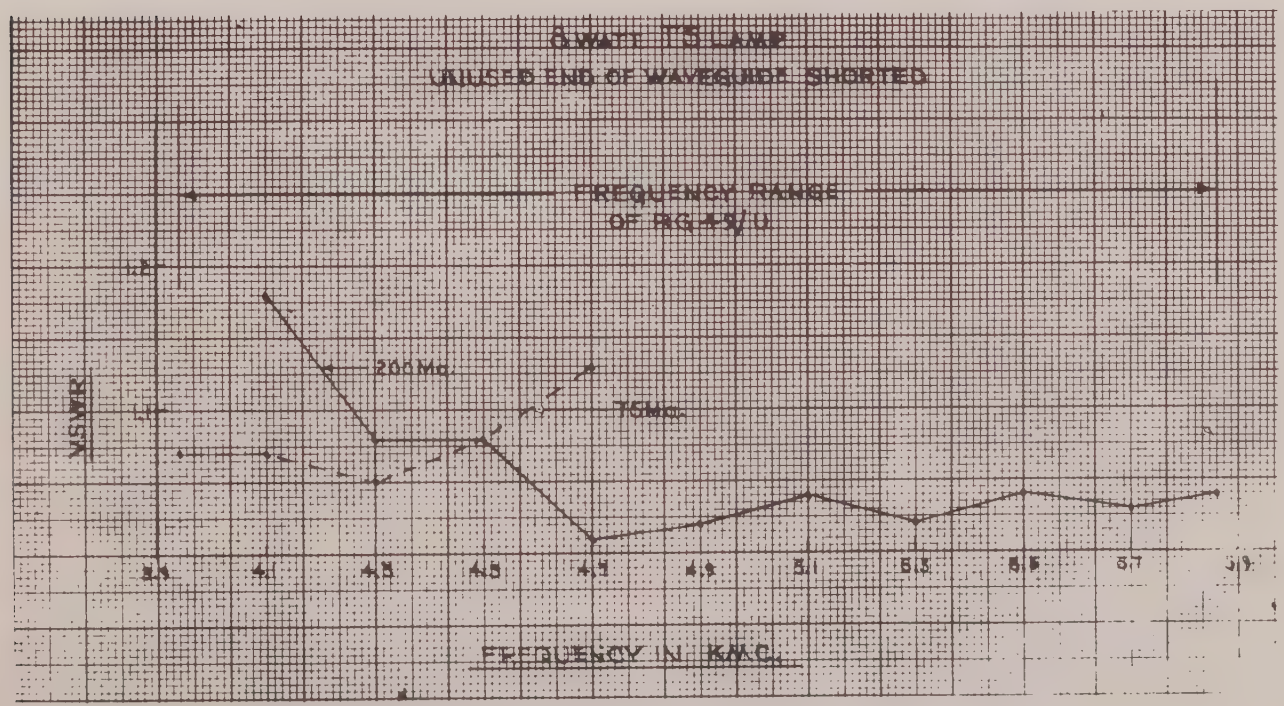


Fig. 4 **RG-49/U,** *VSWR versus Frequency*

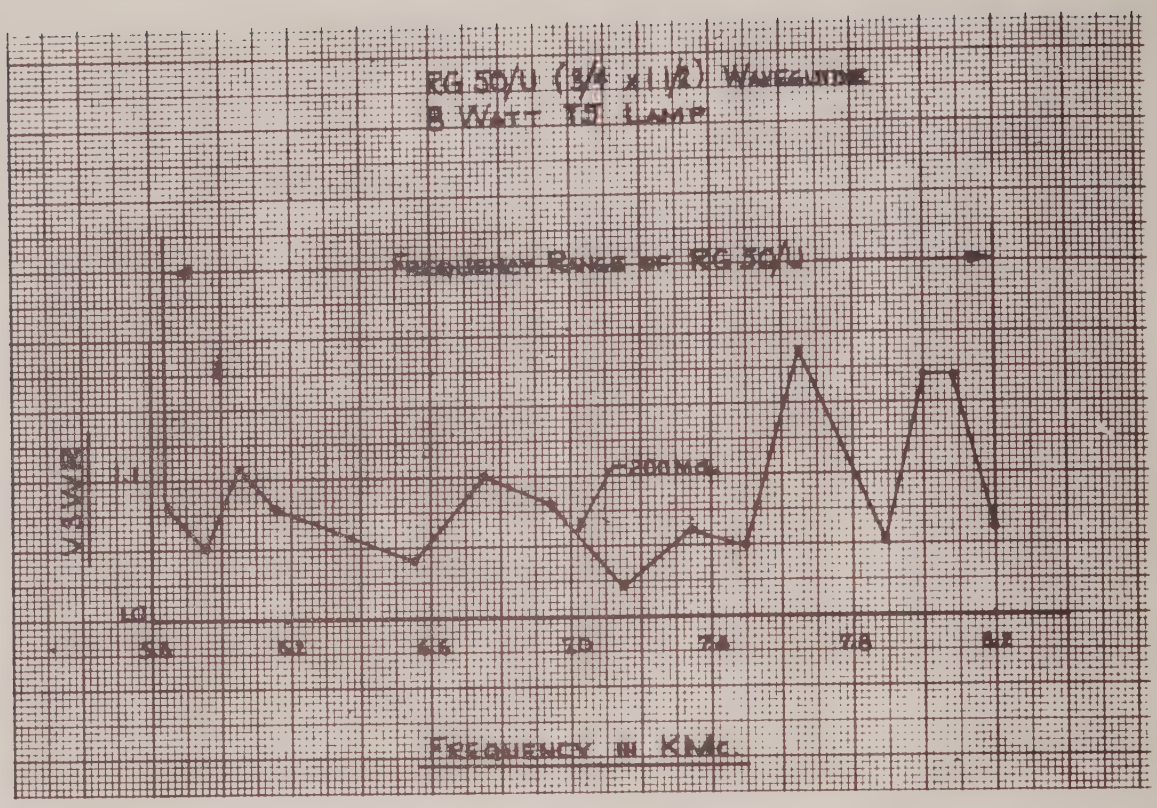


Fig. 5 **RG-50/U,** *VSWR versus Frequency*

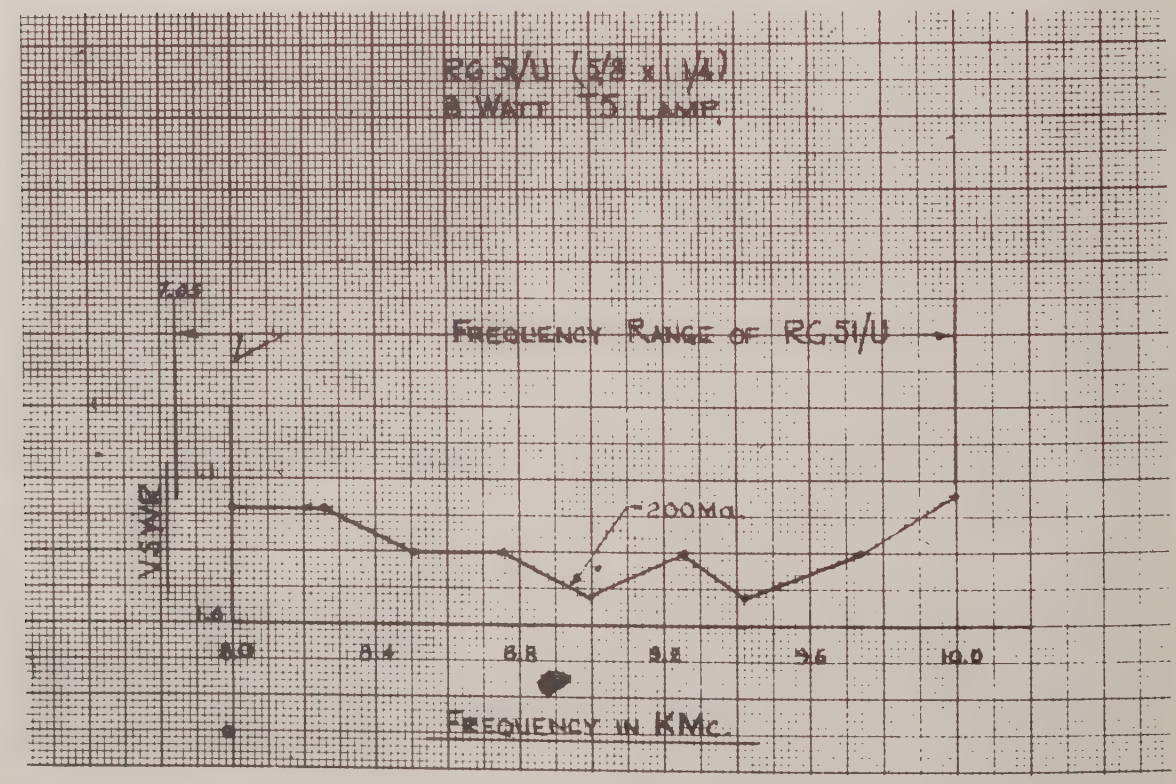


Fig. 6 **RG-51/U,** *VSWR versus Frequency*

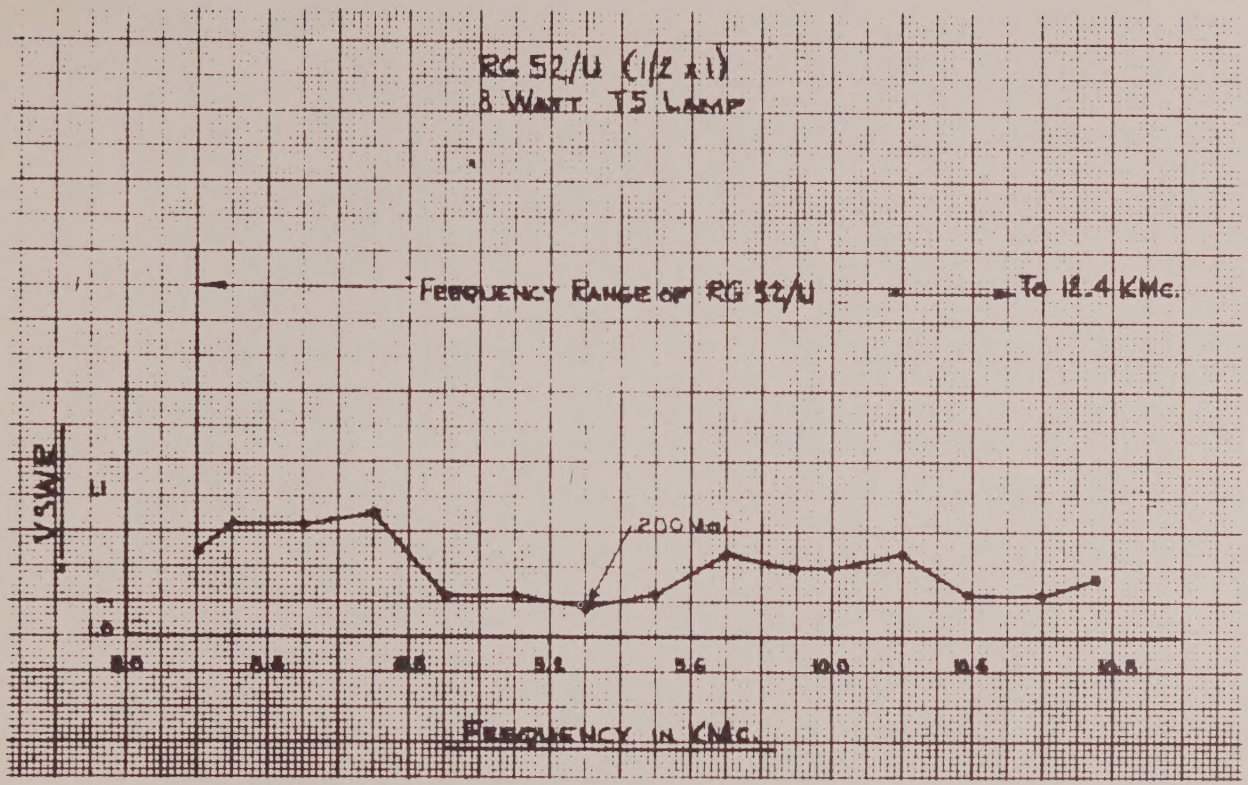


Fig. 7 **RG-52/U** *VSWR versus Frequency*

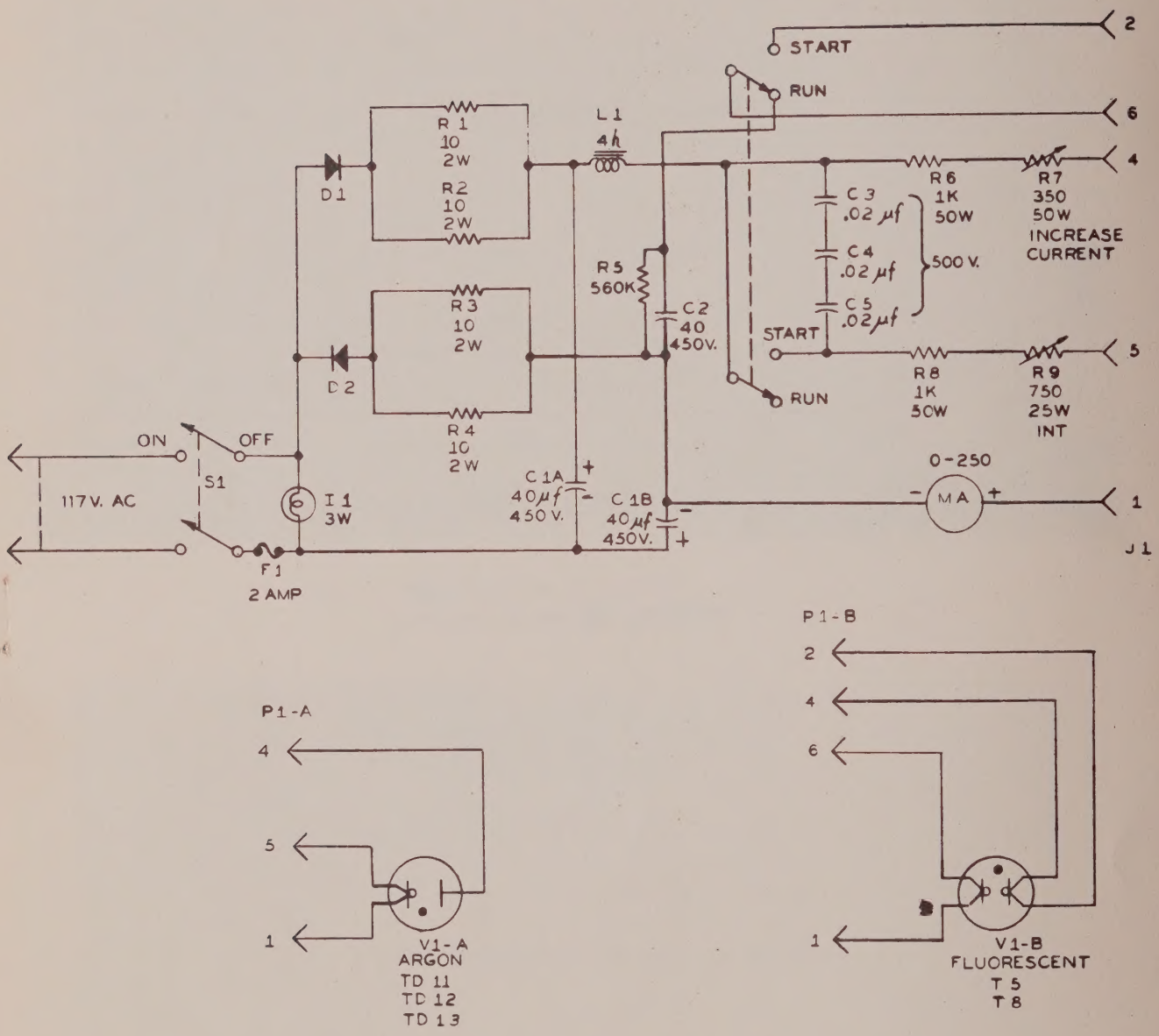


Fig. 8, Complete Schematic, Universal Power Supply
(KC 4401A - 8-26-57)

IFI 5'30